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E. L. Woodward
Western Editor, Chicago

H. C. Wilcox
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C. L. Combes
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Robert E. Thayer
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DECEMBER, 1941

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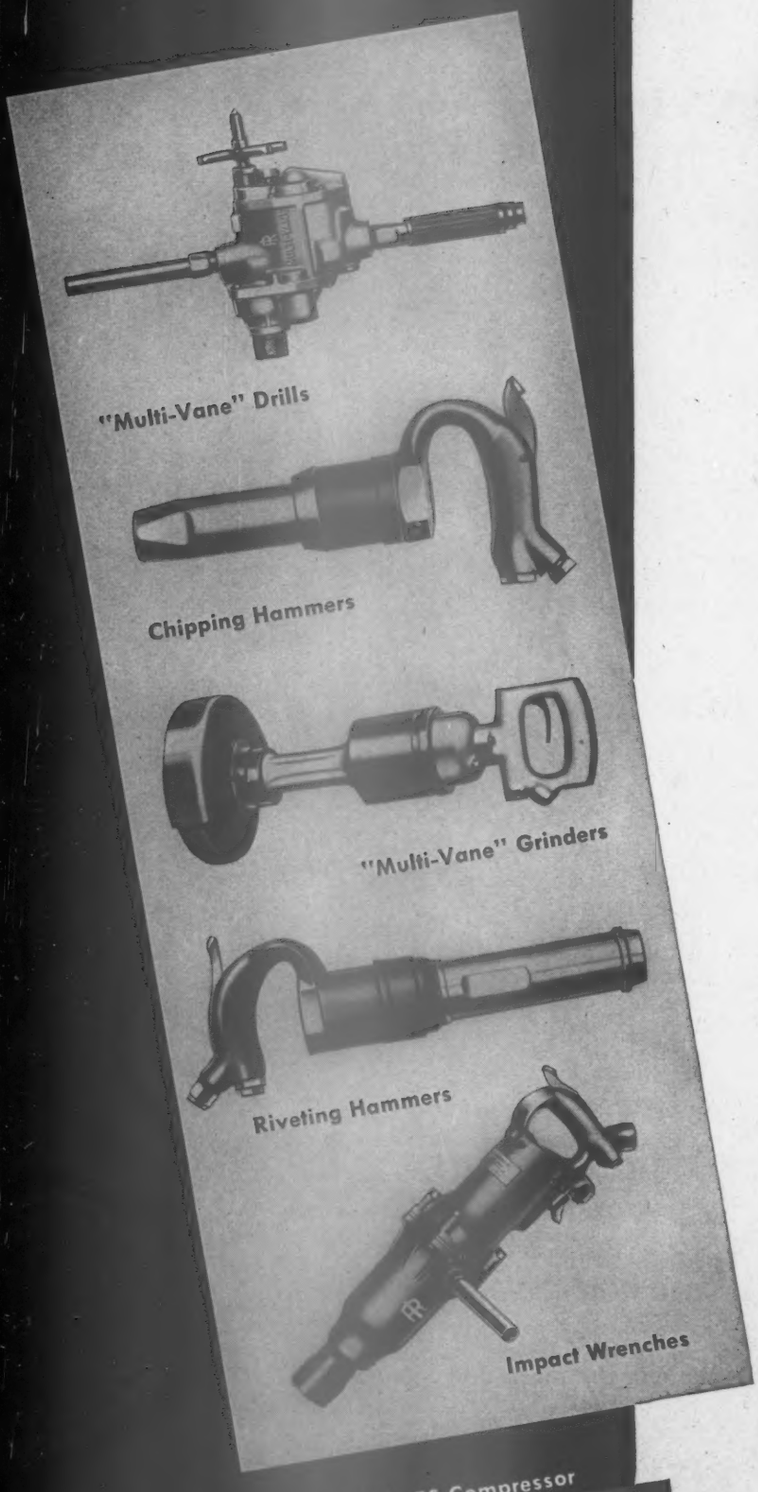

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AIR TOOLS ARE SMALL LIGHT AND FLEXIBLE

Denver and Rio Grande Western Installs

Two-Car Deluxe Trains

"The Prospectors", built by Budd are driven by Diesel-electric power plants mounted under car-floors and are heated from the engine cooling-water—Coach, sleeping-car, dining, and lounge facilities are provided

THE Denver & Rio Grande Western has purchased two stainless-steel passenger trains of two self-propelled cars each from the Edward G. Budd Manufacturing Company. These trains will be used to provide an overnight service via the Moffat Tunnel route between Denver, Colo., and Salt Lake City, Utah. Each of the two cars in each train is equipped with two Diesel-electric traction power plants which are mounted under the car floor, all under multiple-unit control from the operator's cab at the front end of the train. In the two cars are included coach, open-section sleeping-car, single-bedroom, dining, and lounge facilities. There is also a short luggage compartment at the front end of each train.

The arrangement of facilities in these trains is shown on the floor plans. At the front end is a luggage compartment, with operator's section. Behind the luggage compartment is the coach section, seating 44 passengers. To the rear of the latter are roomy men's and women's dressing rooms with toilets.

There are vestibule entrances at the rear of the first car and the front end of the second car.

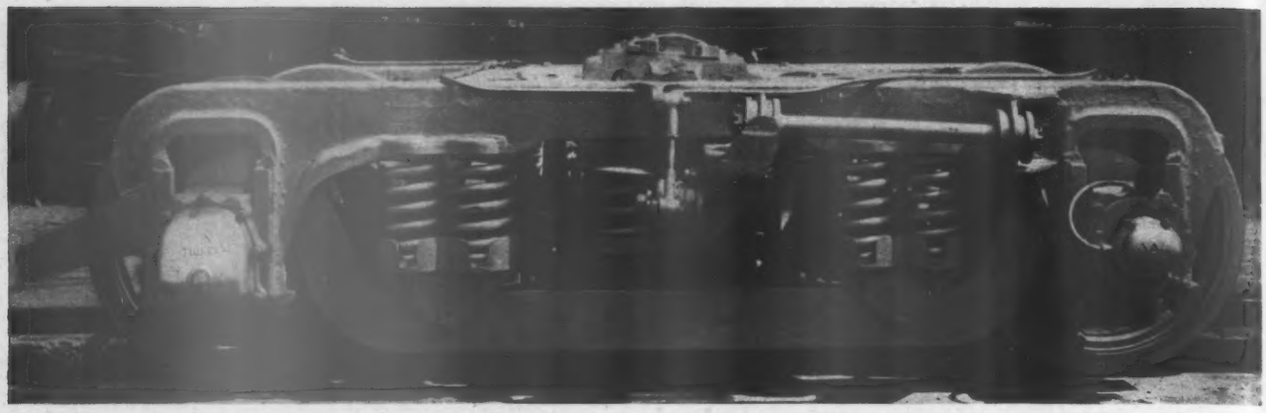
At the front of the second car are women's and men's dressing rooms with toilets. Next is a sleeping-car section with eight upper and lower berths. Behind the open sections are two chambrettes (single-occupancy rooms) each equipped with a folding bed, a folding chair, and complete toilet facilities.

A door between the chambrettes permits them to be combined in a double room of drawing-room size.

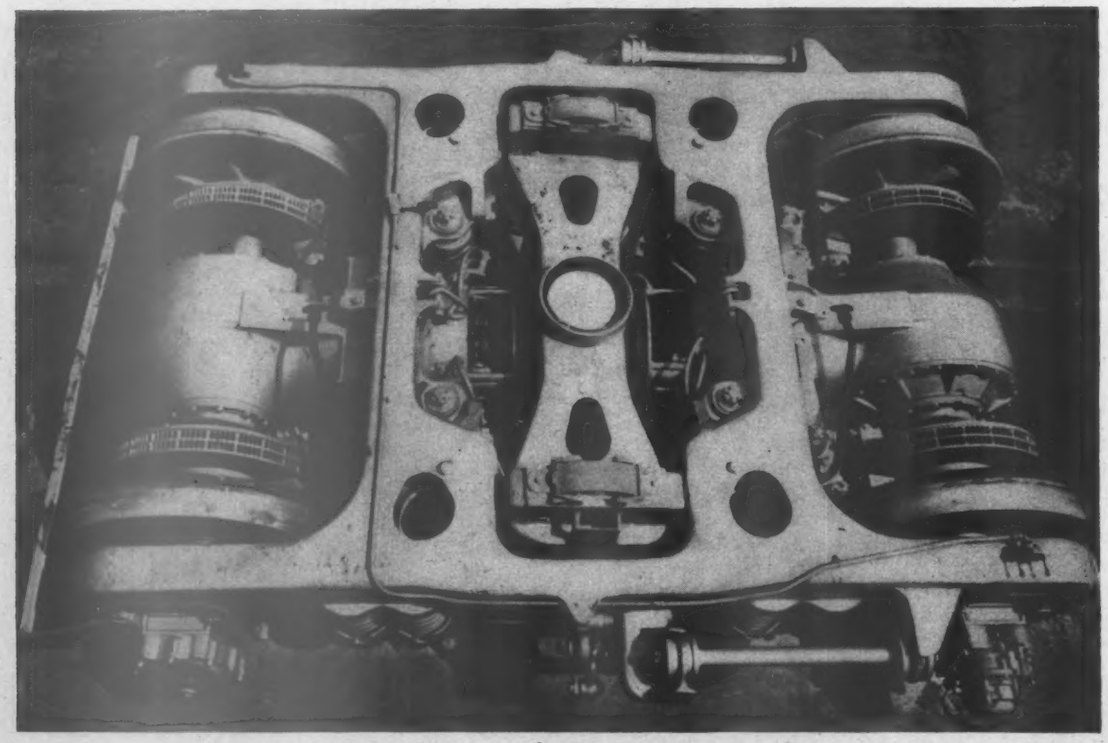
Next to the rear is a buffet kitchen. The dinette, which adjoins the buffet to the rear, consists of two sections with tables, one on each side of the car. At the rear of the dinette two observation-lounge seats face the windows around the end of the car.

As the trains are designed for operation in one direction only, the double coach seats are not reversible. Each seat has an individual reclining back. The decorations are modern and the colors are in soft tones. The center ceilings are in deep cream with coral on the side ceilings, the under side of the luggage racks and the walls down to the floor. The coral tone is also used in the upholstery. The floor is covered with a jaspe linoleum in driftwood gray with aisle strips in a rectangular pattern

The Prospectors of the D. & R. G. W. are two-car de luxe trains for overnight service between Denver, Colo., and Salt Lake City, Utah



The trucks are the single drop equalizer type with coil springs under the bolsters



Looking down on the truck, showing the motor suspension and the disc brake

of marbleized brown and black. The Pantasote window shades are faced inside with a cream colored self pattern.

The sleeping-car sections were developed by the car builder. The upper berth pushes up toward the ceiling horizontally instead of folding upward at an angle.

The sleeping, dining, and observation sections are decorated in a deep flesh tone on the ceilings with gray blue and pearl gray on the walls, which blend with the same colors on the chairs and seats. In the dinette and observation sections the upholstery is in deep tan leather with terra cotta piping.

Power Plants

The two power plants on each car are mounted under the car at diagonally opposite corners near the trucks. Each power plant is enclosed in a soundproof box and consists of a 192-hp. Hercules Diesel engine with General Electric traction and auxiliary generators, an Exide storage battery, a Schwitzer-Cummins normalizer, a heat exchanger, and a panel board containing switches and gages.

The Diesel engine is of the horizontal type, with six four-cycle cylinders of 5½-in. bore by 6-in. stroke, and a total piston displacement of 855 cu. in. Its full power rating is developed at 1,650 r.p.m. The engines are started by special windings in the traction generator, no separate starting motor being required.

In the run between Denver and Salt Lake City the altitude rises from 5,200 ft. to 9,600 ft. in a distance of 39 miles. The purpose of the normalizer is to maintain normal sea-level air pressure for engine operation irrespective of the altitude. It consists of a two-lobe Roots blower and is belt driven from the traction generator. The blower outlets feed into the engine intake.

Engine cooling is effected by a radiator with two fans directly connected to the auxiliary generator on each engine. A thermal control is set in the radiator outlet to advance the fan speed when the water leaving the

Dimensions and Weights of The Prospector

	Front car	Rear car
Length overall, ft.-in.	75-0	78-0
Width inside, ft.-in.	9-3½	9-3½
Height, rail to top of roof, ft.-in.	12-8$^{7}/_{16}$	12-8$^{7}/_{16}$
Height, rail to top of floor, ft.-in.	4-3$^{7}/_{16}$	4-3$^{7}/_{16}$
Height, floor to ceiling, ft.-in.	7-6	7-6
Distance between truck centers, ft.-in.	51-0	54-0
Truck wheel base, ft.-in.	9-0	9-0
Diameter truck wheels, in.	36	36
Journals, nominal size, in.	5½ x 10	5½ x 10
Weights, lb.:		
Total, ready to run	129,820	133,810
Car body, ready to run	84,320	88,310
Trucks	45,500	45,500

radiator rises to a temperature too high to cool the engine. The design is such that the fans operate at the lower speed at all times except when the engine is on full load and the temperature of the atmosphere is above 85 deg. F.

The four power plants on each train are operated through multiple-unit control from a very simple master controller. This may also be used for controlling eight power plants in case a four-car train is desired. The master controller has seven positions which cause the four Bosch engine governors to be set at seven different positions through electro-pneumatic controls. Each position of the controller thus causes the engines to run at one of seven different predetermined speeds ranging from 700 revolutions per minute at idling to 1,650 revolutions per minute at full power output.

To insure maximum engine performance at each governor-controlled speed, an amplidyne control is employed which causes the generator to produce a predetermined power output at that speed. As the train speed increases or decreases and the traction-motor counter-voltage rises or falls, the amplidyne control varies the relation of generator current and voltage so that the product of these values is constant.

Car Heating, Cooling and Ventilation

The system of temperature and ventilation control in the train is entirely automatic and adjusts itself to heating or cooling by a thermostat in the fresh-air duct. At temperatures below 65 deg. F. the system is set up on the heating cycle and above 72 deg. F. on the cooling cycle. In the range of ambient temperatures between 65 deg. and 72 deg. F. neither heating nor cooling is applied, but a manual switch makes either available if desired.

On the heating cycle a circulating pump is in operation which takes the engine cooling fluid from its normal course to the engine radiator and circulates it through the floor and overhead radiators. On the cooling cycle the circulating pump is shut down and thermostatic connections are made with the Freon compressor.

Since the engine jacket water is used for train heating, the control of the engine-water temperature, therefore, performs an important function in the control of the heating system. A Sylphon engine temperature regulator controls the engine-water temperature so that it will not go below 160 deg. F. The thermal element of

One of the power plants in place underneath the car—At the left, the Diesel engine; at the right, the normalizer

this valve is located in the discharge water line from the Diesel engine and the operation of the valve is such that the water from the engine will either go around a by-pass back to the engine water pump or to the radiator to permit cooling. Variable amounts of the water from the Diesel engine may go to the by-pass and to the radiator simultaneously. When the engine-water temperature is low all the water goes through the by-pass and back to the engine. When the engine temperature is high all the water goes to the radiator and then back to the engine.

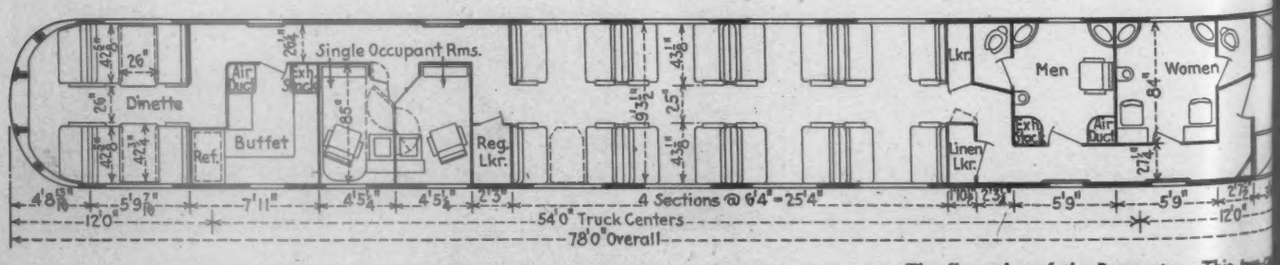
Car cooling is accomplished by Sturtevant electro-mechanical air conditioning with the Fulton-Sylphon electric control. The compressor is a four-cylinder machine driven by a General Electric dual motor consisting of a 20-hp. d.c. element operating from the auxiliary generator and a 15-hp. element operating from standby power. When operating on standby power the d.c. element functions as a generator to supply 64-volt power to the car, and the act of plugging in the a.c. power automatically causes the unloading of all four cylinders of the compressor.

The heating and air-conditioning control system is entirely automatic. The control switch has four positions; namely, "Run," "Yard," "Manual heat," and "Manual cool." Normally, the train crew has only to

Partial List of Materials and Equipment on the D. & R. G. W. Prospector Trains

Stainless steel	Allegheny-Ludlum Steel Corp., Pittsburgh, Pa.
	American Steel & Wire Company, Cleveland, Ohio.
	Carnegie-Illinois Steel Corp., Pittsburgh, Pa.
	The Eastern Rolling Mill Co., Baltimore, Md.
	Republic Steel Corp., Massillon, Ohio.
Truck frames	General Steel Castings Corp., Eddystone, Pa.
Wheel centers	American Locomotive Company, New York.
Axles	Bethlehem Steel Co., Bethlehem, Pa.

Details of the side and underframe construction of one of The Prospector cars



The floor plan of the Prospector—This two-c

The dinette, looking toward the observation-lounge

Roller bearings	The Timken Roller Bearing Co., Canton, Ohio.
Springs	American Locomotive Co., Railway Steel Spring Div., New York.
Brakes	Westinghouse Air Brake Co., Wilmerding, Pa.
Couplers	American Steel Foundries, Chicago. McConway & Torley Co., Pittsburgh, Pa.
Draft gear	W. H. Miner, Inc., Chicago.
Castings	Crucible Steel Co. of America, New York. Dodge Steel Co., Philadelphia, Pa. Treadwell Engineering Co., Easton, Pa.
Diesel engine	Hercules Motors Corp., Canton, Ohio.
Normalizers	Schwitzer-Cummins Co., Indianapolis, Ind.
Amplidyne; traction generators	General Electric Company, Schenectady, N. Y.
Radiator	Young Radiator Co., Racine, Wis.
Cooling fans	B. F. Sturtevant Co., Hyde Park, Boston, Mass.
Water pumps	Worthington Pump and Machinery Corp., Harrison, N. J.
Air compressor	Westinghouse Air Brake Co., Wilmerding, Pa.
Batteries	Electric Storage Battery Co., Philadelphia, Pa.
Insulation	Gustin-Bacon Mfg. Co., Kansas City, Mo.
Air conditioning	B. F. Sturtevant Co., Hyde Park, Boston, Mass.
Heating	The Fulton-Sylphon Co., Knoxville, Tenn.
Anemostat	Anemostat Corp. of America, New York.
Grills	Barber-Colman Company, Rockford, Ill.
Lighting	Safety Car Heating & Lighting Co., New York.
Lamps; wire	General Electric Company, Schenectady, N. Y.
Conduit	Republic Steel Corp., Massillon, Ohio.
Receptacles	The Pyle-National Company, Chicago.
Sash	Hunter Sash Co., Inc., Flushing, L. I., N. Y.
Glass	Hires-Turner Glass Co., Philadelphia, Pa. Pittsburgh Plate Glass Co., Pittsburgh, Pa. Pressed Prism Plate Glass Co., Chicago.
Roller curtains	The Pantasote Co., Inc., New York.
Curtain fixtures	The Adams & Westlake Co., Elkhart, Ind.
Carpet; upholstery; drapes	L. C. Chase & Co., Inc., New York.
Cork; linoleum	Armstrong Cork Co., Lancaster, Pa.
Kitchen equipment	Angelo Colonna, Philadelphia, Pa.
Coach seats; vanity chairs	Troy Sunshade Co., Troy, Ohio.
Lounge chairs	Heywood-Wakefield Co., Gardner, Mass.
Water cooler	Marquette Railway Supply Co., Chicago.
Lavatories	Crane Co., Chicago.
Hoppers	Duner Co., Chicago.
Pipe covering	Gustin-Bacon Mfg. Co., Kansas City, Mo.
Paint	E. I. du Pont de Nemours & Co., Wilmington, Del.

put the control switch in either the "Run" or "Yard" position.

The cooling system is controlled in two steps. When the temperature in the return-air stream drops below 74 deg. F., half of the cylinders of the compressor are made inactive by a solenoid by-pass valve and a solenoid valve closes off half of the evaporator surface. If the temperature goes below 72 deg. F., the compressor is shut down; above 74 deg. F., the compressor is running with full load.

Lighting

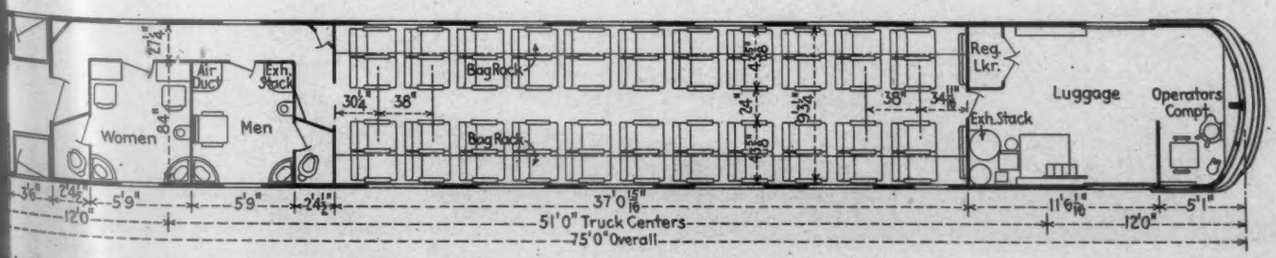
Fluorescent lighting in Safety fixtures is used exclusively, except for the cab and vestibules. In the coach are ceiling fixtures for general illumination and bag-rack units for reading. In the sleeping-car sections and cabinettes the 9-in., 6-watt lamp units have manual starting switches. All other lighting is accomplished with 15-in., 14-watt lamps with magnetic starters. At the front end of the train a movable spotlight supplements the headlight on curved track.

Trucks and Couplers

The four-wheel trucks are General Steel Castings single drop-equalizer type, with coil springs under the bolsters as well as between the truck frames and equalizers. Each axle is driven by a high-speed propeller-type motor through bevel gears, the commutator end of the motor being suspended between the coil springs mounted in the truck transom. The wheels have cast-steel spoke centers with steel tires, 36 in. in diameter. This type of wheel was adopted because the Budd disc brake relieves the wheel rims of the temperature rise

(*Continued on page 511*)

The coach interior



designed for operation in one direction only

Milwaukee Builds

Large Welded Box Cars

Five hundred 50-ton cars have exceptionally large cubic capacity and embody unique features in design—Roofs, ends and sides prefabricated and put together on assembly line

THE Chicago, Milwaukee, St. Paul & Pacific has recently completed building at the company shops, Milwaukee, Wis., five hundred 50-ton box cars which are entirely fabricated by welding and include a number of other interesting features of construction aside from being about the largest 50-ft. 6-in. box car possible to build within the A. A. R. clearance limits. The light weight of the car is 48,200 lb. and the cubic capacity, 5,157 cu. ft., the ratio of load limit to gross load, 71.5 per cent and of light weight to cubic capacity, 9.35 lb. per cu. ft.

The other features of special interest, mentioned, include the following: Leak-proof side doors, mounted in rigid steel frames which are welded as units into the car sides and give increased strength at a point where it is greatly needed; two-piece car ends and narrow adjoining side pans, also prefabricated and welded into strong structural units; car floor between the doorways protected against wear by a perforated steel plate and sealer; plywood inside lining panels 54 in. wide at the doorways readily renewable when damaged; individual floor boards which also may be renewed without disturbing the side lining; easily removable clean-out boards to permit thorough blowing out back of the lining at both sides and ends; nailing post positions inside the car indicated by vertical rows of dashes burned into every other lining board by means of an electric marker.

The 500 new 50-ton box cars have been constructed by the Milwaukee to meet the ever-increasing demand for box cars of this capacity, not equipped with automobile loading devices, but adapted for the general loading of finished lumber, wood pulp, plywood and mill products, originating primarily in the Northwest. In addition, these 50-ft. 6-in. cars are required for the loading of light, bulky commodities, such as electric refrigerators, radios, furniture, cereals, tinware and empty cans and for mixed commodities which, to prevent damage, cannot be loaded high. The all-commodity freight rate to the Pacific Coast, which prescribes a carload minimum of 30,000 lb. without regard to size of car, also causes shippers using this rate to insist upon being supplied with 50-ft. cars.

The new box-car design embodies the more or less familiar Milwaukee construction with horizontal-rib side sheet strips united by electric spot welding. The car sides, ends and posts are made of USS Cor-Ten steel, the center sill being a special composition steel supplied by the Inland Steel Company. The door pans and corner pans are pressings made of both Yoloy and Nax low-alloy high-tensile steels.

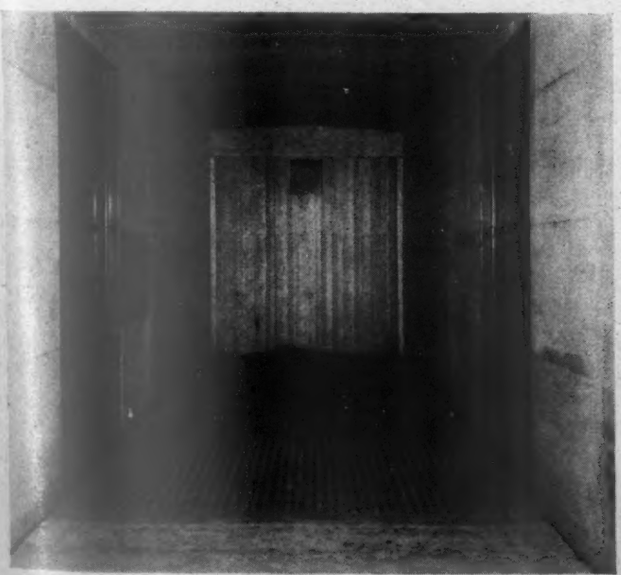
The side doors are Youngstown, and the car roofs and ends, Standard. The order for draft gears was divided

Milwaukee 50-ton box car

The car underframe and side frame construction—The prefabricated center floor section is being applied

between five manufacturers of recognized draft gears which more than meet the A. A. R. minimum requirements. The Bettendorf truck sides and bolsters are designed to incorporate the truck stabilizing device supplied by the Standard Car Truck Company. Other equipment includes Stucki side bearings, Schaefer brake hangers, Creco brake-beams and bottom-rod supports and uncoupling mechanism supplied the Standard Railway Equipment Company.

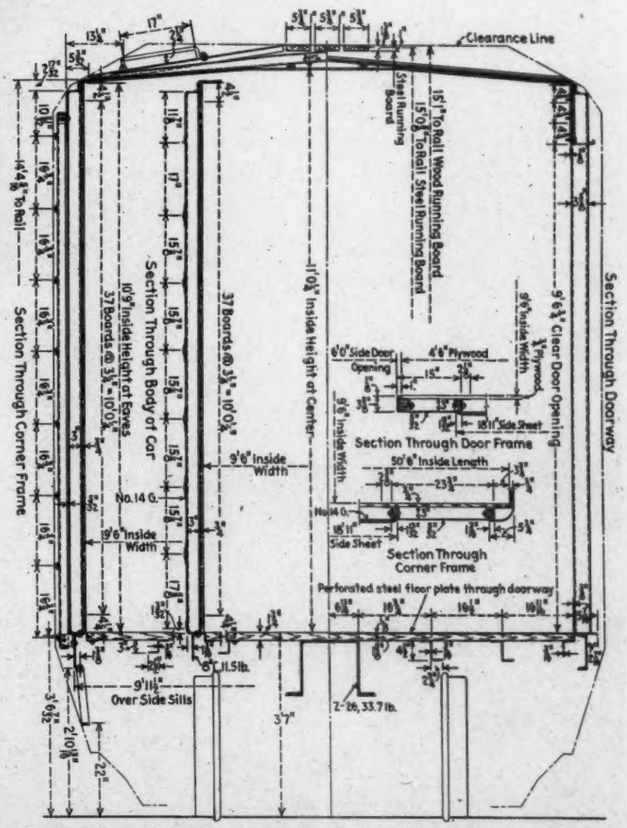
The bolster center filler and rear draft-lug casting,



Interior of the car—The prefabricated floor at the doorways is surfaced with perforated steel wear plates

General Dimensions and Weights of New Milwaukee 50-Ton Box Cars

Length over striking castings, ft.-in.	51-7⅜
Inside length, ft.-in.	50-6
Inside width, ft.-in.	9-6
Inside height at center, ft.-in.	11-¼
Inside height at eaves, ft.-in.	10-9
Distance between truck centers, ft.-in.	40-7⅜
Width over side sheets, ft.-in.	10-1⅝
Width over side plates, ft.-in.	10-1$^{13}/_{16}$
Width over roof sheets, ft.-in.	9-8¼
Width over side sills, ft.-in.	9-11½
Height—top of rail to top of floor, ft.-in.	3-7
Height—top of rail to running board—steel, ft.-in.	15-⅝
Height—top of rail to eaves, ft.-in.	14-4$^{9}/_{16}$
Width over door locks—Camel door, ft.-in.	10-8
Side door opening, ft.-in.	9-6¾ high by 6-0 wide
End door opening A end, in.	16 high by 18½ wide
Width over side ladders, ft.-in.	10-7⅜
Light weight, lb.	48,200
Load limit, lb.	120,800
Capacity, cu. ft.	5,157
Ratio load limit to gross load, per cent	71.5
Ratio light weight to cubic capacity, lb. per cu. ft.	9.35



Cross-sections and sectional details of the Milwaukee 50-ton box car

which is another feature of the design of this car, is also supplied by the Bettendorf Company which furnishes the lumber door. The order for couplers and yokes was divided between Buckeye and Gould. The air brake equipment is Type AB built by Westinghouse. The hand brakes are Equipco and Universal types. The car wheels are cast iron, manufactured at the Milwaukee foundry. Plywood for the ceiling and top end pieces was supplied by the Harbor Plywood Corporation. Side and end lining and the floor boards are of Douglas fir. The defect-card holder is the Railway Products Company's design.

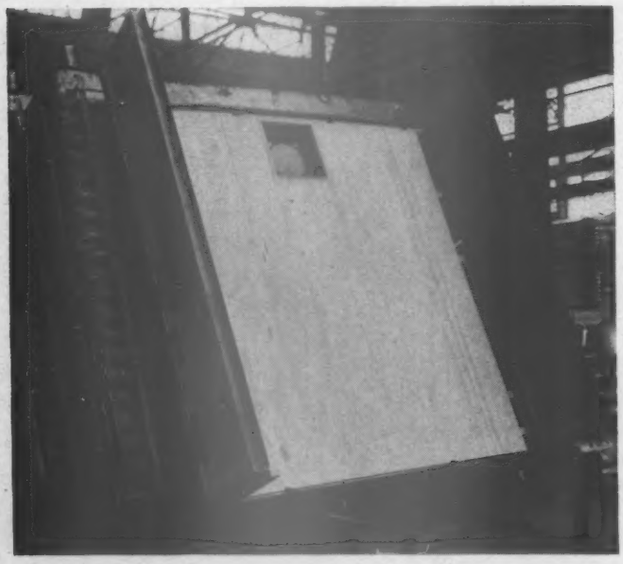
How the Increased Capacity Is Secured

Referring to the table of dimensions, it will be noted that the limiting width in this car, as in practically all box cars, is the distance over door roller housings. The increased capacity in this instance is secured primarily by revising the side door and door fixture construction so as to permit designing the car 4 in. wider on the

inside than is the case with the A. A. R. standard car. The rollers in this design are placed underneath the door and the Camel door fixtures and operating mechanism are redesigned for a minimum projection beyond the outer door surface. The outer surfaces of the side sheets also are spaced so as to bring the width over sides ladders just within the required limit.

The capacity of the car is also increased by raising the car roof as high as practicable to give an inside height at the eaves of 10 ft. 9 in. and at the center of 11 ft. ¼ in. Referring to the drawing, it will be observed how both the roof and side construction are designed to fit just within the A. A. R. clearance lines. Increased roof height is made possible by the use of a 3/16-in. Safety steel tread plate instead of the conventional running board, and applying the lateral running board with only ¼ in. clearance between the roof sheet and the bottom of the running board, flanged edges being placed in the lower connection of the roof for stiffness.

How the car roof and running board are pre-assembled



Unit car ends completed and ready to fit into the car structure

General Method of Assembling the Car Structures

The new Milwaukee box cars were turned out of the shop at the rate of seven cars a day, the assembly line making one move every 68 min. The principal electric welding machines used in building this type of car include a large hydromatic spot welder, a pedestal spot welder, a series welder, and numerous machines with leads for individual welding operators. Underframes, sides, ends, rooms, etc., are fabricated as units.

In the construction of the underframe, for example, the center and side sills are delivered to the erecting shop and necessary punching done on the spacing machine adjacent to the underframe jig. The center-sill sections are assembled in the jig together with the combined cen-

Assembled car sides ready for application to the underframe

ter filler and rear-draft-lug casting, also the striking casting, these parts being welded together by the electric process. The side sills, bolsters and cross bearers are applied in the jig and the entire underframe welded together at the first underframe position. At the second position, the underframe is turned upside down for finish welding and the application of couplers and draft gears, air-brake equipment including levers, rods and pipes, etc.

Each side section, approximately 19 ft. long by 10½ ft. high, is assembled under a series welder and tack welded. It is then moved to the hydromatic welder for completion of the electric-spot welding operation. The door frame, 8 ft. 9 in. high by 10½ ft. wide, consists of door pans, threshold and side plate, rigidly welded together and including a pre-assembled door with all door fixtures applied. Two side sections and the door frame are then assembled in a jig to form a single car side and completely welded from the inside, then being turned over for completion of the exterior welding.

The car ends are assembled in a stationary jig, the two sections of each end being butt-welded together and the brake step and hand brake riveted on the upper section.

Putting on the car roof after the sides and ends have been assembled

The pre-fabricated lumber door and end ladders also are applied. The end is then turned over on the jig so that corner pans with the upper elements and auxiliary side sill can be welded in place. The wood filler pieces, the end lining, the grab-irons and side ladder are applied.

The roof is constructed in a special jig, in which the individual sheets are drawn together to the exact length desired and welded in place. The prefabricated running board is applied in this position. The roof is then turned over on an adjacent jig and wood fillers and plywood ceiling panels put in place; the former are held by bolts and the latter with screws. The 8-ft. section of car floor at the doorway, protected by steel plate, is also prefabricated by assembling four pieces of the steel plate, perforated with 2-in. round holes, in a jig where they are welded together, applied over the wood flooring and bolted in place.

At No. 1 erecting position, the car sides, doorway floor plate, ends and roof are set in position on the underframe which rests on its own trucks. The car then moves to No. 2 position where it is squared up and tacked together by electric welding. In this position the doorway floor plate is welded to the threshold plate and auxiliary side plate by continuous weld, thereby accurately fixing the inside width of the car, squaring up the car permanently, and, by tying the two side sills together, a girder is formed which strengthens the car at its weakest point. At positions 3 and 4, the car is completely welded.

The car then moves outside the shop to the spray booth where the underframe and inside are primed.

On returning to the shop at the wood track, the rest of the car floor is laid and bolted. The nailing posts and door plywood panels are applied, the latter being made just wide enough so that two 19 ft. lengths of tongue-and-groove lumber will complete the side lining. The side lining includes lower and upper clean-out boards and is toe-nailed so that no nail heads are exposed to work out. The end lining includes side clean-out boards and a top plywood piece.

A special moisture-proof floor sealer is applied over the steel wear plate at the car doors and the joint between the car sides and ends and the floor are also effectively sealed against the entrance of moisture at this critical point. The air brakes are tested and the car stenciled.

D. & R. G. W. Prospector Trains

(*Continued from page 507*)

caused by rim braking. On all axle journals are Timken roller bearings.

The truck brakes are the Budd disc type. Double cast-iron discs are mounted on the inside hub of each wheel; the inner and outer faces of the discs are separated by radial vanes which act as impellers for the dissipation of the heat generated in braking. Brake shoes are of composition lining, one on each side of the disc and covering approximately one-fourth of the circumference. These shoes are operated by a pair of tongs fulcrumed on a support lying just outside of the disc radius. The outer extremities of the tongs are coupled to the piston in an air cylinder. The coefficient of friction between the brake shoes and the cast-iron discs is said to be practically constant through a wide range of application pressures, temperatures, speed, and sequence of application. Deceleration is, therefore, approximately uniform from the beginning of the application until the train stops. The emergency deceleration rate on The Prospectors is set at about 3.3 miles per hour per second.

The brake cylinders are attached by bolting flanges to the sides of the motor case, and the torque reaction is taken through the motor suspension springs.

The air brakes are the Westinghouse H.S.C. system with electro-pneumatic control and decelostat wheel-slip control. Air is supplied by two Westinghouse DH-25 motor-driven compressors located in the baggage room of the front car. Sanding equipment is applied on each truck and is operated manually by the engineman or automatically in emergency and when the decelostat relays operate.

The car bodies differ in some respects from the customary Budd type of structure. Strain-gage measurements indicate that they can withstand 400,000 lb. end compression, including a safety factor of two, which is adequate to permit a total train weight of 600,000 lb.—approximately double the normal two-car train consist. The sides below the window sill are corrugated plate girders. The corrugations, similar in form to those on the roof, are spot welded to the vertical frame members. The structure above the belt rail is the truss type.

The couplers between the cars are the American Steel Foundries controlled-slack type and are fitted with special Miner draft gears designed for these trains. McConway & Torley retractable couplers are installed at the front and rear ends of the trains.

A. A. R. To Limit

Car Types During Emergency

A. A. R. asks members approval of commitment to O. P. M. restricting orders to 13 box, open-top, and flat-car designs recommended by the Car Construction Committee

In the belief that the successful completion of the railroad program to own 1,800,000 freight cars by October, 1942, is contingent upon affirmative action by the O. P. M. to obtain the required material, the member roads of the Association of American Railroads have been asked by J. J. Pelley, president, in a letter dated November 5, to authorize the officers of the association to state to the O. P. M. that during the emergency future orders for new box, open-top, and flat cars will conform to 13 designs. These were recommended in a report of the Car Construction Committee of the Mechanical Division. The 13 designs comprise three box cars, one auto-box car, two hopper cars, four gondola cars, and three flat cars. In his letter Mr. Pelley points out that by thus restricting the number of designs of new equipment O. P. M. expects to increase the capacity of car-building facilities and to simplify the material supply problems. "As the matter now stands," he said, "procurement of material for new freight cars is contingent on acceptance by the railroads of some program of simplified practice and a firm commitment to that effect to the O. P. M."

In recommending these designs, it is the thought of the Car Construction Committee and the General Committee of the Mechanical Division that cars built during the present emergency should be of such dimensions as will freely interchange over all main lines. Should there be need for cars of special dimensions for handling special shipments or should there be need of other types of cars for special commodities, the individual railroads originating such traffic should provide the equipment for it either by altering existing cars or by providing new cars to the required dimensions or of the required type only in such quantity as are required to handle the special traffic.

The designs proposed by the Car Construction Committee are as follows:

Box Cars

The first of the box cars is the A. A. R. 40-ft. 6-in. car with an inside height at the eaves of 10 ft. The inside width is 9 ft. 2 in. and the clear door opening 6 ft. This car is built for both 40- and 50-ton nominal capacities. Designs are shown in A. A. R. Supplement to the Manual of the Mechanical Division (1500 Series of plates). All car builders have available designs, dies, patterns, etc., and are fully equipped to build these cars.

With the exception of a 6-in. increase in height, which involves the lengthening of side sheets, end sheets, door posts, corner posts, side posts, side doors, etc., the second box car is identical with the A. A. R. car with 10 ft. inside height, for which all car builders have designs. These designs can be readily modified to suit the 10-ft. 6-in. inside height and no additional dies or patterns are required. Cars to these dimensions have been built by the Pressed Steel Car Company, to their drawing 65885-D, for the Chicago, Rock Island & Pacific, and are being built by the American Car and Foundry Company for the Missouri Pacific.

The third box car design recommended by the committee is for a 50-ton car with an inside length of 50 ft. 6 in., an inside width of 9 ft. 2 in., an inside height at eaves of 10 ft. 6 in., and a clear door opening of 8 ft. All car builders are said to have dies and patterns for these cars which are the same as for the A. A. R. 40-ft. 6-in. car with 10 ft. inside height. The proposed general design drawing has been completed under the supervision of the Committee on Car Construction.

The proposed auto-box car design is of the same general dimensions as the 50-ft. 6-in. box car, except for a clear door opening of 15 ft. The design of the underframe for the two 50-ft. 6-in. box cars will be the same with the exception that the auto-box car will have additional reinforcement at the 15-ft. double side doors. Dies for the main cross-bearers and cross-ties will also be different. The proposed general design drawing of this car has been completed under the supervision of the Car Construction Committee. Provision is made in one end for double end doors as an alternate. This car is suitable for the application of loading devices.

Hopper Cars

Designs for the 50- and 70-ton cars are shown in the A. A. R. Supplement to the Manual of the Mechanical Division (600 Series of plates, built-up riveted construction) and many thousands of them have been built. The committee reports that all car builders have available designs, dies, and patterns and are fully equipped to build these cars.

Gondola Cars

No A. A. R. gondola-car designs have been developed. The Car Construction Committee reports that this is chiefly due to differences in service requirements in the various sections of the country. The eastern roads use solid-bottom gondola cars, principally for steel-mill products and to a lesser extent for coal, sand, etc. The western roads use general service gondola cars for coal, gravel, road-building material, etc., many of which are equipped with dumping arrangements. Based on a review of designs built during recent years, the committee has selected the following types as most suitable for these requirements:

Gondola Car—Fixed End—This is a car, the designs, dies, and patterns for which are available at the Bethlehem Steel Company, in both wood and steel floor construction (Drawing C-27252-C and Drawing C-28263A, respectively) having steel sides. These 50-ton cars, which have been built for the Atlantic Coast Line, have

(*Continued on page 515*)

Boiler Makers' Association Report on the

Effect of High Temperatures

By Ray McBrian*

THIS is a progress report on the studies of the effect of aging properties and effect at elevated temperatures and surface decarburization. In addition to the damping capacity tests for aging there is now under construction an X-ray diffraction unit for the study of internal stresses and the identification of complex compounds occurring in microscopic cracks. By the use of this equipment it is hoped to secure some knowledge as to the mechanism of

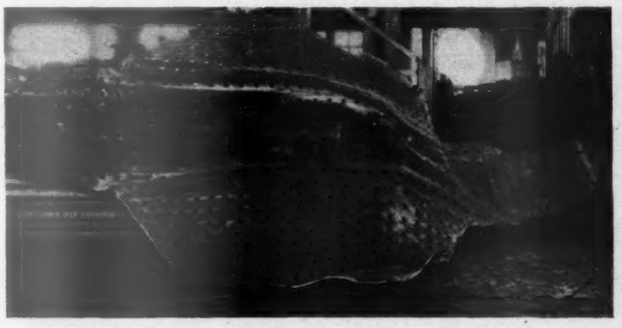


Fig. 1—Portions of the firebox sheets showing discoloration from excessive temperature

the various types of cracking associated with firebox and boiler problems.

In spite of the interest that has been manifested failures continue to occur and on our own road we are trying to correlate the study of service failures with research. For example, our unfortunate explosion of passenger

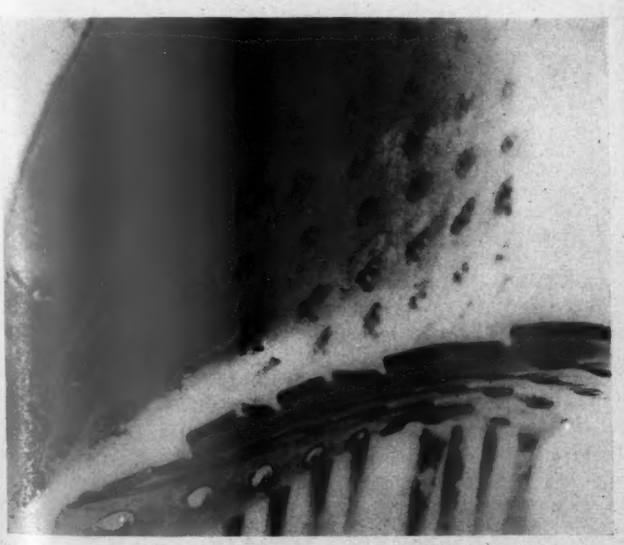


Fig. 2—The syphon and a portion of the crown sheet at point of rupture

locomotive No. 1804 brought out forcibly the added factor of safety which would be available by the use of materials with higher strength at elevated temperatures.

A novel feature of this investigation was the use of color photography. Fig. 1 shows portions of the crown sheet, door, and sides of firebox syphons. It will be noted that the syphons display a normal steely color; the crown sheet and portion of the door show the discoloration from overheating. The origin of the failure was at a point adjacent to the combustion-chamber syphon and the highest point of the crown sheet. [Note: While the author's original slides were in color, which is not reproduced here, the conditions he emphasizes are discernible in these illustrations.—EDITOR.]

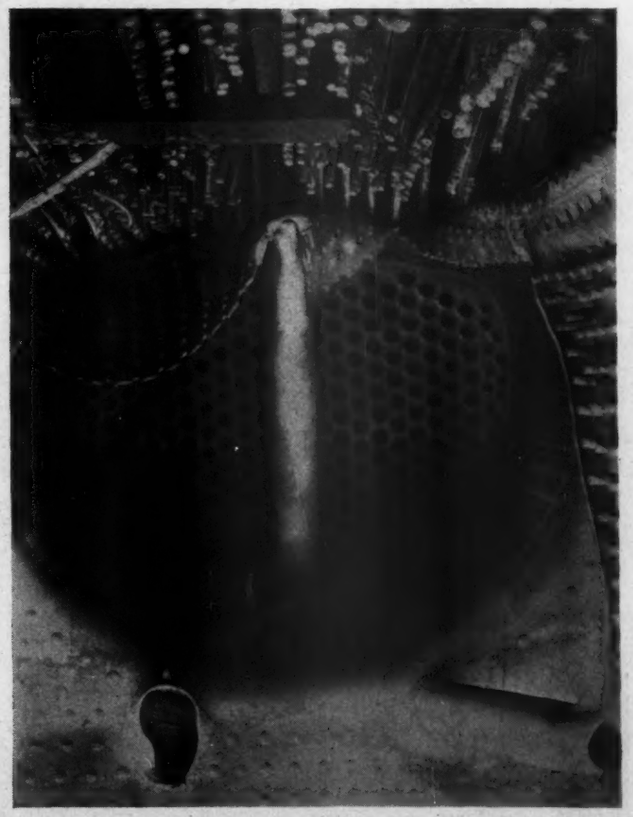


Fig. 3—The condition of the interior of the firebox is shown here

Fig. 2 shows the combustion syphon and portion of the crown sheet at the point of rupture. The reduction of area around the staybolt holes and the horizontal color line coincident with the fourth row of syphon stays may readily be seen.

Fig. 3 is a photograph taken inside the firebox showing the combustion-chamber syphon, the back flue sheet, and the same portion of the crown sheet as that shown in Fig. 2. The discoloration shows down to the eighth row of flues indicating the extreme low-water condition at the time of the explosion. From the color line in the fire-

* Engineer of Standards and Research, Denver & Rio Grande Western.

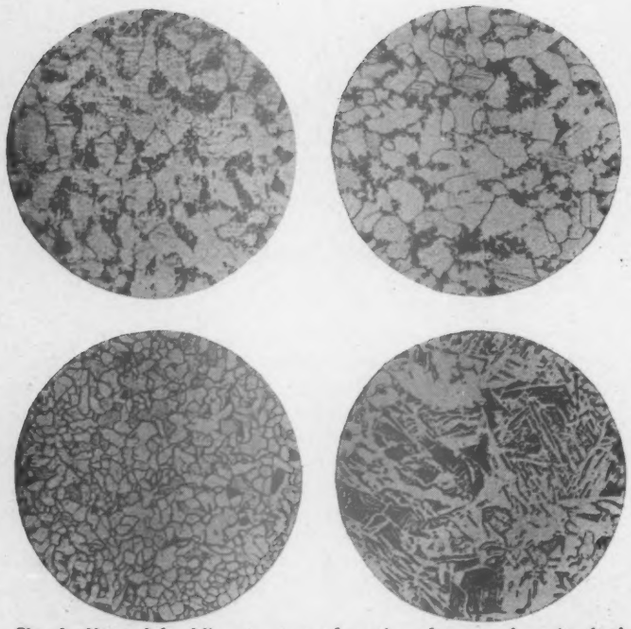


Fig. 4—Upper left: Microstructure of portion of crown sheet involved in the explosion when heated to 1,350 deg. F.—Upper right: A comparative piece of crown sheet heated to the same temperature—Lower left: A piece of the same sheet heated to 1,650 deg.—Lower right: Another piece of the same sheet heated to 1,800 deg. F.

box and from the boiler dimension it has been calculated that the water level at the time of the explosion was at least 2,750 gal. below the bottom of the gage glass. Of passing interest it will be noted that the combustion-chamber syphon adds considerable structural stiffness to the crown sheet as shown in the manner in which the crown sheet sagged on both sides of the syphon.

Color pictures made it possible to show conditions in this firebox after the explosion which could not have been shown by the use of black-and-white photography.

The photographs show that the primary cause of this explosion was overheating from low water. Metallurgical examination and study indicates that by the use of a material with greater strength at elevated temperatures this failure might have been prevented.

The microstructures found at various locations around the firebox showed that maximum temperature was reached at a point coincident with the origin of the explosion and established the maximum temperature as between 1,350 deg. and 1,400 deg. F.

Fig. 4 shows the microstructure of a portion of the crown sheet which had been heated to this temperature. For comparison, pieces of the crown sheet were heated to 1,350 deg. F., 1,650 deg. F., and to 1,800 deg. F.

The effect on the microstructure of heating to these different temperatures, is shown and by comparison with these photographs the temperature to which the crown sheet had been heated was determined. The structure obtained by heating to 1,350 deg. F. was almost identical to that shown in the crown-sheet sample. All of the micrographs were made at 200 diameters.

To determine the strength of the crown sheet at the temperature at which it failed, tensile tests were made at 1,385 deg. F. Tensile tests were also made of carbon-molybdenum fire-box steel at this same temperature, for comparison. The molybdenum content of the firebox steel was taken at this same temperature, for comparison. It was one-half of one per cent.

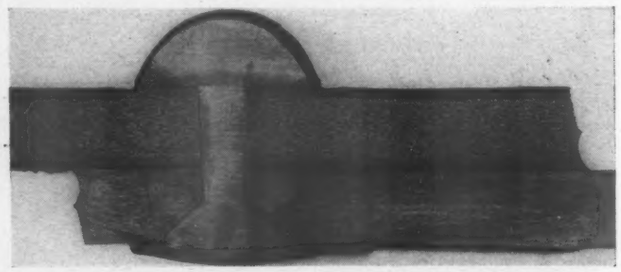


Fig. 6—An etched cross-section of a riveted seam showing the sharp edges in the rivet hole

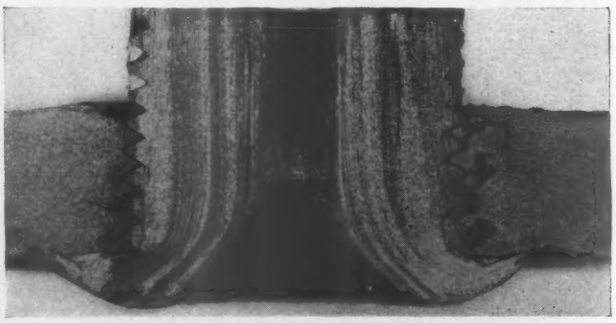


Fig. 7—Section of sheet at the root of the thread showing a crack originating in the interior of the sheet

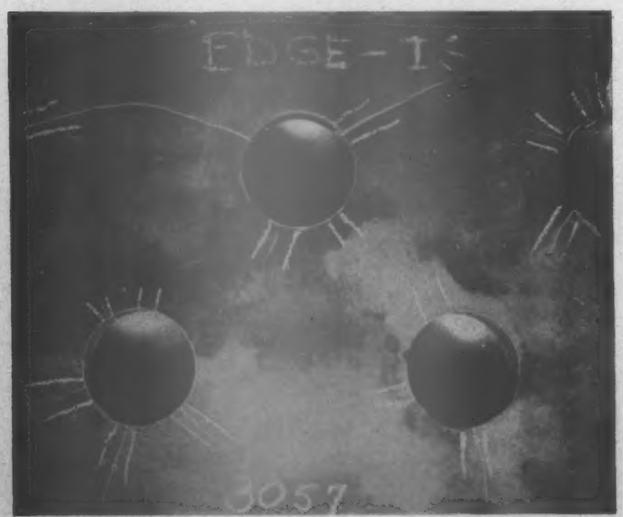


Fig. 5—Cracks in a boiler seam as indicated by Magnaflux testing

The results of these tests indicated that the tensile strength of the crown sheet where it failed was approximately 5,600 lb. per sq. in., or only one-ninth the value at room temperature. The carbon-molybdenum firebox steel at this temperature had a tensile strength of 13,400 lb. per. sq. in. or more than double the strength of plain carbon steel. To demonstrate that the reduction in strength due to overheating alone could cause the failure of this firebox, the following calculations were made:

Using the formula $$S = \frac{Pa^2}{4\,T^2}$$

Where S = maximum working fibre stress, lb. per sq. in.
P = boiler pressure, lb. per sq. in.
a = staybolt pitch, in.
T = thickness of plate, in.

A ⅜-in. plate and a staybolt pitch of 4 in. give a working stress of about 8,000 lb. per sq. in. for 280 lb. boiler pressure.

From the elevated temperature tests it was shown that for the plain carbon steel the strength at 1,385 deg. F. was only 5,600 lb. per sq. in. or 2,400 lb. per sq. in. lower than the working stress at that temperature. It was found then that the boiler pressure alone was sufficient to cause a failure when the temperature of the crown sheet approaches 1,350 deg. F. Also, it was found that the molybdenum steel, due to its higher strength at elevated temperatures, would not have failed at this working stress at 1,385 deg. F.

The results of this investigation emphasize the necessity for recognizing the importance of the elevated-temperature strength properties of boiler and firebox materials.

The importance of fabrication practices is further demonstrated as shown by the failure illustrated in Fig. 5 which shows cracks in a section of a boiler-shell seam. These cracks are outlined with Magnaflux powder and indicated by white lines. The micrographs showed these cracks to be trans-crystalline, and this brings out the important point of properly identifying failures.

It was found that these cracks originated at the sharp edges of the holes. Some had referred to them as embrittlement cracks; the micrographs show they were trans-crystalline. This brings out the need for recognizing the importance of removing all sharp edges from riveted seams.

Fig. 6 is an etched cross section of a riveted seam showing the sharp corners in the rivet hole and the deformation of the plate from high caulking pressure. This practice helps to provide the conditions necessary to get failures from stress concentrations which can develop intergranularly.

Fig. 7 is of a section of firebox side sheet and staybolt, showing a crack originating in the interior of the sheet at the root of a thread where the stress is concentrated at a sharp corner. This etched section again demonstrates the need for understanding the elevated temperature properties of both the side sheet and staybolt materials. The side sheet was corrugated, indicating lack of the necessary strength under load at operating pressure and temperature. The effect of corrugation is to cause the threads to engage mostly on the fire side of the sheet. In consequence of such action the staybolt bears all its load at the last few threads. Since the head of the bolt is at a relatively higher temperature, the net effect especially with the ordinary iron or steel bolts, is that the bolt is much weaker, due to its loss of strength from temperature effects.

We have found that by the use of such an alloying element as molybdenum, we can secure an iron or steel alloy with increased strength at elevated temperature.

To Limit Car Types During Emergency

(*Continued from page 512*)

an inside length of 41 ft. 6 in., an inside width of 9 ft. 6 in., and an inside height of 4 ft. 8 in.

Gondola Car—Fixed Ends, with Drop Bottom—The designs, dies, and patterns for this 50-ton car are available at the General American Transportation Corporation (their drawings 5-1595 and 4-3599), and were built for the Illinois Central. They have an inside length of 41 ft., an inside width of 9 ft. 6 in., an inside height of 5 ft., and have 16 drop doors in the floor.

Gondola Car—Drop Ends—Designs, dies, and patterns for these cars are available at the Bethlehem Steel Company to their drawings C-27425-C. They are 70-ton cars and were built for the Lehigh Valley. They have an inside length of 52 ft. 6 in., an inside width of 9 ft. 6 in., and an inside height of 3 ft. 6 in. The floors are wood.

Mill Type Gondola—Drop Ends—This is a car, the design, dies, and pattern for which are available at the General American Transportation Corporation to their drawing 5-1608. These cars, which were built for the Atchison, Topeka & Santa Fe, have a nominal capacity of 70 tons, an inside length of 65 ft. 6 in., an inside width of 7 ft. 9 in., and an inside height of 3 ft. 6 in. These cars have steel floors.

Flat Cars

No designs of flat cars have been developed by the A. A. R. The designs which follow were selected by the committee after reviewing cars built during recent years.

The first is a 50-ton car, designs, dies and patterns for which are available at the Pullman-Standard Car Manufacturing Company to their drawing 509-F-63-I. These cars were built for the Union Pacific. The length over the floor is 53 ft. 6 in., the width over the floor, 10 ft. 6 in., and the height, rail to top of floor, 3 ft. 7¼ in. They have a wood floor.

The second design recommended by the committee is for a 70-ton car the designs of which are available at the Greenville Steel Car Company to their drawing 16393. They were built for the Erie and have a length of 53 ft. 6 in. over the floor, a width of 10 ft. 6 in. over the floor, and a height, top of rail to floor, of 3 ft. 5 in. The floor is of wood.

The third flat-car design recommended by the committee is a 70-ton car built on a cast-steel underframe, the patterns for which are available at the plant of the General Steel Castings Corporation, Granite City, Ill. The cars were built to Pennsylvania Railroad drawing A402605C. The length over strikers is 50 ft., the width over the floor 9 ft. 3 in., and the height rail to top of floor, 3 ft. 5⅛ in. The cars have a wood floor.

The report of the Car Construction Committee, to which general arrangement drawings are attached, concludes as follows: "The foregoing recommendations have been submitted to the car builders who advise that the designs recommended do not present any difficulties in the matter of dies which they may be called upon to make in the event of the purchase of any of these cars. This has particular reference to the gondola car and flat cars as the car builders are now in possession of all dies for the box and hopper cars recommended and can without much difficulty prepare dies for the auto-box cars recommended. The car builders mentioned as having available designs, patterns, etc., for gondola and flat cars have all expressed their willingness to supply to other car builders the necessary drawings so that they may construct cars to these same designs."

Small But Busy Private Railroads are being operated by the Army's Quartermaster Corps in 168 posts, camps and stations, according to the War Department. These operations involve 140 locomotives, 89 locomotive cranes, 1,481 cars operating over 563 mi. of track. Of the total trackage approximately 497 mi. is standard gage, 52 mi. narrow gage and 14 mi. 5 ft. gage [the latter presumably refers to Army trackage in the Canal Zone which is so gaged to connect with the tracks of the Panama railroad]. The equipment of these railroads ranges from tiny narrow-gage locomotives to the 100-ton Diesel-electric switcher at Camp Blanding, Fla., which handles a standard freight train of 75 to 80 loaded cars.

Measurement of

Stresses in Car Wheels

Part I†

By Reid L. Kenyon and Harry Tobin*

Application of a method for studying stresses in structures to the study of stresses in car wheels as used in the research laboratories of the American Rolling Mill Company

STATIC loading tests have always shown wrought steel wheels to have a large excess of strength to resist rupture but the effect of variations in manufacturing processes and of conditions of service under railway cars could not be thoroughly investigated by static loading tests. During recent years the railroads have stepped up the entire tempo of their operations and there has been an increasing need for a quantitative method for measuring the stresses in car wheels.

Service conditions previously were not severe enough to raise any question as to whether the wheels were adequate as to strength and design but the advent of higher speed trains and the need for weight reduction has served as an impetus to the development of quantitative methods for stress measurement in wheels.

The method described in this paper is basically that used by the National Bureau of Standards [1, 2, 3, 4] for studying stresses in bridges, airplanes and other structures. The authors have applied the method to the study of stresses in car wheels, and during its use in the Research Laboratories of The American Rolling Mill Company over a period of about six years, some modifications have been made in the previously published methods which greatly reduce the labor of computation, and also increase the accuracy of the results in calculating the stresses in any direction, based upon the actual measurements.

In the early stages of this development, it was necessary to make the computations by a graphical method such as the one described by Osgood and Sturm.[3] This was a slow method at best, although with experience, two men working together on computing and drawing could solve a rosette in 20 minutes. Later, a trigonometric solution of the graphical method was developed which reduced the time to 10 minutes for only one man. Next came graphical charts, modified from those described by Stang and Greenspan,[2] which reduced the time to about 5 minutes per rosette. The slide rule developed by the authors now makes it possible for a single operator to compute rosettes at rate of about one a minute.

The adoption of a proper technique is highly essential to accuracy and a full description is given of that which has been developed in this laboratory.

Although the general theory is discussed in numerous texts on mechanics and the mathematical theory of elasticity, the special cases involved in this method are usually presented separately and it is assumed that the reader is fully familiar with the application of the theory to these special cases. Usually this results either in an incomplete understanding of the subject or at the least requires the assumption by the reader that the theory is probably correctly applied and he should take the correctness of the deductions for granted. As far as the authors are aware, this is the first complete discussion in one paper of the theory and the working details for measurements of internal stresses by the "rosette" or "dyadic circle" method.

The purpose of the authors in preparing such a complete presentation was to bring together in readable form the entire story of this method—its theory, and its technique.

The requirements for a satisfactory method of determining stress may be divided into those of a practical and those of a theoretical nature. It is of practical importance that the method should be accurate and reproducible, should be non-destructive so that it can be used to study the effect of service conditions and be easily and quickly applicable to the wheels to be studied, either in the laboratory, in the plant or in railroad service. From the theoretical standpoint the method should be quantitative rather than qualitative, it should determine the combined stresses and the maximum stress, and it should determine the stresses at selected positions rather than give integrated results over the entire wheel.

The methods that have previously been employed include cutting the wheel into concentric rings or making a radial cut from hub to rim or combinations of these two. Differences between measurements made before and after cutting are taken as indications of the internal stresses in the wheel. Obviously, none of these methods meets the most important of the requirements that have been mentioned; first of all they require the destruction of the wheel as a complete structure, they do not indicate the stress at selected points but "average" the stresses over large areas and finally they are not quantitative. None of these previous methods can be used to measure successive increments of stress change due to service or other imposed conditions, and none of them gives the results of the combined stresses which are acting in dif-

* Associate director and research engineer, respectively, Research Laboratories, The American Rolling Mill Company, Middletown, Ohio.

† Part II of this study will appear in a subsequent issue and will cover the practical application of this method of analysis which is developed theoretically in Part I.

[1] W. R. Osgood, Determination of Principal Stresses from strains on Four Intersecting Gage Lines 45-deg. Apart, Bureau of Standards Journal of Research, Vol. 15, Dec., 1935, R. P. 851.

[2] Ambrose H. Stang and Martin Greenspan, Graphical Computation of Stresses from Strain Data, Bureau of Standards Journal of Research, Vol. 19, Oct., 1937, R. P. 1034.

[3] W. R. Osgood and Rolland G. Sturm, Determination of Stresses from Strains on Three Intersecting Lines and its Application to Actual Tests. Bureau of Standards Journal of Research, Vol. 10, May, 1933, R. P. 559.

[4] A. H. Stang, M. Greenspan, and W. R. Osgood, Strength of a Riveted Frame Having a Curved Inner Flange. Bureau of Standards Journal of Research, Vol. 21, Dec., 1938, R. P. 853.

ferent parts of the wheel (maximum stress and its direction). The radial cut from rim to hub relieves some of the internal stress but not all due to the rigidity of the wheel section, and in any event it cannot separate the plate, hub, and rim stresses. Measurements across the radial gap in concentric rings are misleading due to bending stresses which may result from stress gradients from inside to outside circumference of the rings. This condition has been observed and is illustrated by the results of a test described in the Appendix.

Development of Method of Determining Stresses

The development to be described consists, for the most part, in the application of certain principles of the mathematical theory of elasticity with modifications to fit the particular problem in hand. For the benefit of the engineers and metallurgists who are in a position to apply the method to a study of stresses in wheels, we will present not only the practical points in the technique but also the underlying principle based on the above theory.

This theory teaches that:

1.—In a simple rod subject to uni-directional stress (longitudinal tension) a strain measurement in a single direction (longitudinal) will adequately determine the magnitude of the applied stress. Although this applied stress produces the greatest strain in the longitudinal direction, there is a definite magnitude of strain in every direction.

2.—The lateral movement caused by this longitudinally applied stress is usually expressed as a ratio of the lateral to the longitudinal strain. (Poisson's Ratio.)

3.—If a body is subject to the application of multi-directional stresses the effect of each one can be calculated separately from strain measurements made in the direction of the corresponding applied stress but the net effect of the simultaneous applications of several stresses can be determined only by the Theory of Combined Stresses.

4.—The Mathematical Theory of Elasticity furnishes a basis for the determination of stresses in any direction at a point in a body provided that suitable strain measurements can be made in three mutually perpendicular planes through this point.

5.—This usually involves experimental difficulties but it is often sufficient to determine the stress in all directions in a single plane through the body (frequently one external surface). This is quite satisfactory when the applied stresses are in this plane and when the maximum strain will be in the plane of the applied stresses.

6.—The condition just referred to is known as "plane stress" in which all applied stresses are parallel to the surface upon which the strain measurements are made. The assumption that this condition is fulfilled, which seems quite justified in the cases to be discussed, simplifies the problem by limiting it to only two dimensions.

7.—When the condition of stress at a point is fully determined it is found that there is one direction in which the stress is maximum, in the algebraic sense, and that it is minimum, in the algebraic sense, in a direction at right angles thereto. These are known as the principal stresses.

8.—The principal stresses fully determine the state of stress in all directions at that point in the body and these principal stresses, in turn, can be determined from strain readings made on three or more co-planar gage lines which intersect at this point.

The application of these principles from the Theory of Elasticity makes it possible to meet all the theoretical requirements for a satisfactory method of determining stresses. It gives quantitative values of stress at selected positions corrected for the effect of simultaneously-acting combined stresses and it should be possible to apply it non-destructively. It will be shown later that the practical requirements are also met.

The pattern of three or more intersecting gage lines has been generally described as a "rosette" and this has given rise to the term "Rosette Method" to describe this procedure for determining the condition of stress at a point in a plane when subjected to plane stress.

Theory Underlying the Rosette Method

In the following presentation one purpose has been to develop the theory underlying the rosette method but the main objective has been to work out modifications of the usual equations that would increase the accuracy of the results and at the same time result in greater ease of computation.

In developing these equations it is necessary to consider the fundamental concepts of stress and strain in an elastic body. It should be remembered in all of the following discussion that all deformations are limited to the elastic range. The expressions for strain will be developed first.

When a body is subjected to external forces it undergoes a certain amount of deformation which in general results in a relative displacement of any two points in the body. This displacement may cause the line joining the two points to (1) change in length only, (2) change in direction only or (3) change in both these respects. In a few simple cases the forces may be applied in a simple manner and the resulting strains can be easily defined and measured but in the case of bodies of complex shape the analysis of the strain becomes more complicated.

A logical presentation requires an examination of the two simple cases first, followed by their combination. Let us consider first the case in which the line joining the two points changes only in length. This is called simple extension.

In Fig. 1 the two points are O and b and the displacement of b to b' is clearly the result of two simple extensions, one in the X direction and one in the Y direction. The unit extensions are equal to du/dx and dv/dy respectively. Convention has adopted the symbols e_x and e_y to represent the unit extension or strain in the X and Y directions respectively, so we may write:

$$e_x = \frac{du}{dx} \text{ and } e_y = \frac{dv}{dy} \quad \ldots\ldots\ldots\ldots (1)$$

The case in which the line joining the two points changes only in direction is called shear.

In Fig. 2 the two points are a and b and the line connecting them changes from ab to ab'. The angle γ_x is a numerical measure of the shear strain, which in this case is parallel to the Y axis (i. e., the Y direction). It is always small and therefore can be represented by the tangent of the angle.

$$\gamma_x = \frac{dv}{dx} \quad \ldots\ldots\ldots\ldots (2)$$

Similarly in Fig. 3 the movement in the X direction would be measured by the angle bcb' which again could be represented by the tangent of the angle.

$$\gamma_y = \frac{du}{dy} \quad \ldots\ldots\ldots\ldots (3)$$

The angles are measured in radians but since the values are small they are equivalent to strain in inches per inch if these are the units used.

Shear may occur in both the X and Y directions simultaneously and this more general case is illustrated in Fig. 4.

The prism $Oabc$ is distorted to $Oa'b'c'$ which involves shear in both of these directions. The total shear is measured by the angle representing the difference between angle $a'Oc'$ and a right angle. This is the sum of the two small angles aOa' and cOc' which can be

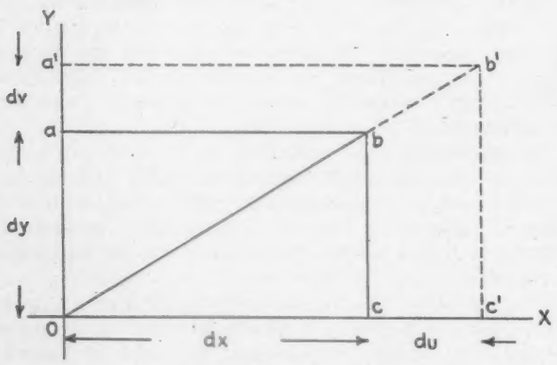


Fig. 1

measured by their respective tangents du/dy and dv/dx. But these quantities by equations (2) and (3) are the expressions for shear in the X and Y directions respectively. Therefore the total shear

$$\gamma_{xy} = \gamma_y + \gamma_x = \frac{du}{dy} + \frac{dv}{dx} \quad \ldots\ldots\ldots\ldots (4)$$

When the line joining the two points changes in both length and direction we have the most general case and the solution of this gives the components of strain at the point. These will be expressed in an equation of three terms. The first two give the simple extension in terms of the extensions in the X and Y directions and the third gives the shear component in both the X and Y directions.

In Fig. 5 the two points are O and b and it will be seen that when b is displaced to b' the line Ob changes in both length and direction. For the development of the equations for the components of strain at the point O it will be convenient to take a very small prism whose base is shown in Fig. 5. The line Ob is the diagonal of rectangular base $Oabc$.

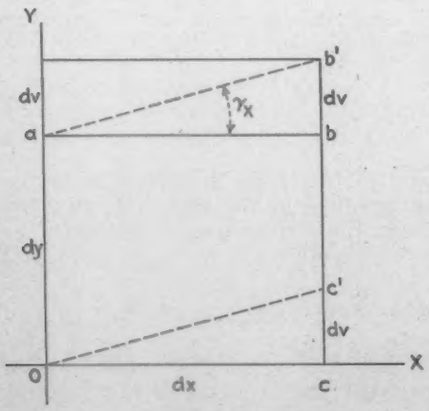


Fig. 2

In application of external forces which displaces b to b' distorts this rectangle $Oabc$ into the parallelogram $Oa'b'c'$ which does not have the same area as the original rectangle.

The following conventions will be adopted in connection with Fig. 5:

1. The original dimensions of the rectangle $Oabc$ will be taken as dx and dy and the original length of the diagonal ds.
2. The angle between OA and OX will be called α.
3. The projections of Ob' on the X and Y axes will be $dx + du$ and $dy + dv$ respectively.
4. The projections of Ob' on OA is Ob'' and equal to $ds + dR$.
5. Since the angle $b'Ob''$ is very small it can be assumed that angles bfg and $Ob'f$ are equal to α.
6. The unit extension of the diagonal Ob will be called e_A.

From the construction, the component bb'' of the displacement bb′ is equal to

$$bb'' = dR = bg + gb'' = du \cos \alpha + dv \sin \alpha \ldots\ldots (5)$$

The unit extension along the diagonal Ob is

$$e_A = \frac{dR}{ds} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

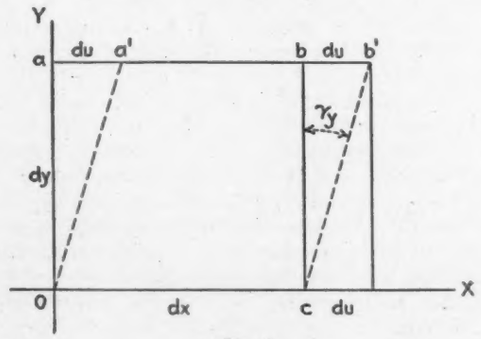


Fig. 3

The next step is to express the strain e_A in terms of the strain components along the X and Y axes. Although the area of the parallelogram $Oa'b'c'$ is, in general, not the same as that of the original rectangle $Oabc$, the deformation is the same as though it took place in two

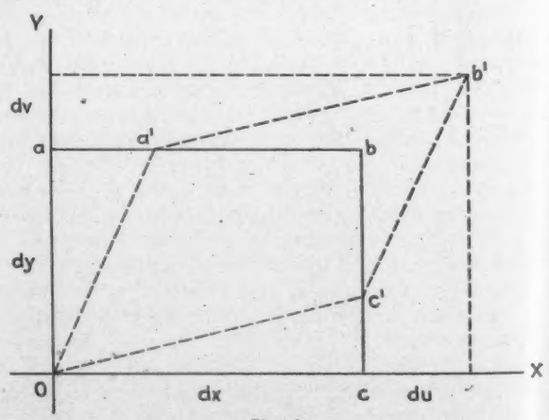


Fig. 4

steps; first, by two simple extensions, as in Fig. 1, into a rectangle of the same area as $Oa'b'c'$ and, second, distorted by shear, as in Fig. 4, into the parallelogram $Oa'b'c'$ as shown in Fig. 5.

The component of the displacement bb' in X direction is du and this is made up of simple extension of the

prism *Oabc* in the direction *OX* and a simple shear in the same direction.

For each unit of dx there is a portion of du which is due to simple extension in the X direction. Analytically this is represented by the partial derivative, $\delta u/\delta x$ and the total displacement in the X direction due to simple extension would then be $(\delta u/\delta x)\ dx$. Similarly, for each unit of dy there is also a portion of du which is due to simple shear in the X direction which can be represented by $\delta u/\delta y$. The total displacement in the X direction due to this shear is $(\delta u/\delta y)\ dy$. The total displacement in the X direction due to both simple extension and shear is then expressed by the equation,

$$du = \frac{\delta u}{\delta x}\,dx + \frac{\delta u}{\delta y}\,dy \qquad (7)$$

By the same procedure the following equation is derived for the displacement in the Y direction,

$$dv = \frac{\delta v}{\delta y}\,dy + \frac{\delta v}{\delta x}\,dx \qquad (8)$$

These values for du and dv can be used to get another expression for e_A. Substituting them in equation (5) and then substituting the obtained value for dR in equation (6) we get:

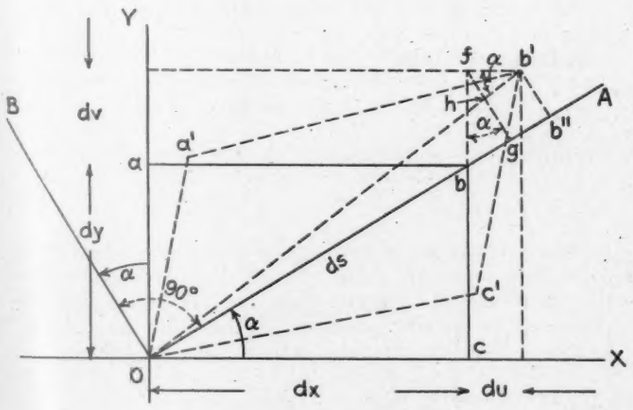


Fig. 5

$$e_A = \frac{\delta u}{\delta x}\cdot\frac{dx}{ds}\cos\alpha + \frac{\delta u}{\delta y}\cdot\frac{dy}{ds}\cos\alpha + \frac{\delta v}{\delta y}\cdot\frac{dy}{ds}\sin\alpha + \frac{\delta v}{\delta x}\cdot\frac{dx}{ds}\sin\alpha \qquad (9)$$

From the construction of Fig. 5 $dx/ds = \cos\alpha$ and $dy/ds = \sin\alpha$. Furthermore we may make $\delta u/\delta x = e_x$ and $\delta v/\delta y = e_y$ since these are unit extensions in the X and Y directions. Also, $\dfrac{\delta u}{\delta y} + \dfrac{\delta v}{\delta x} = \gamma_{xy}$.

Substituting these values in equation (9)

$$e_A = e_x\cos^2\alpha + e_y\sin^2\alpha + \gamma_{xy}\sin\alpha\cos\alpha \qquad (10)$$

To remove the second power terms we can make the following substitutions in equation (10) based on trigonometric relationship of the functions of double angles.

$$\sin\alpha\cos\alpha = 1/2\sin 2\alpha$$
$$\cos^2\alpha = 1/2\,(1+\cos 2\alpha)$$
$$\sin^2\alpha = 1/2\,(1-\cos 2\alpha)$$

which gives

$$e_A = 1/2\,(e_x+e_y) + 1/2\,(e_x-e_y)\cos 2\alpha + 1/2\,\gamma_{xy}\sin 2\alpha \qquad (11)$$

The unit extension along the direction OB in Fig. 5 is obtained by substituting (90 deg. $+\ \alpha$) for α in equation (11)

$$e_B = 1/2\,(e_x+e_y) - 1/2\,(e_x-e_y)\cos 2\alpha - 1/2\,\gamma_{xy}\sin 2\alpha \qquad (12)$$

We now have expressions for the extension in any element making an angle α with OX (equation 11 or with OY (equation 12) and the next step is to determine the shearing strain. The total shear may be considered as the sum of the simple shears in the A and B directions similar to the treatment of Fig. 4 and equation (4).

In Fig. 5, $b'b''$ may be considered as a component of the displacement bb' The ratio of $b'b''$ $(=dQ)$ to Ob is equivalent to a simple shear in the direction OB.

$$\gamma_A = \frac{b'b''}{Ob} = \frac{dQ}{ds} \qquad (13)$$

From the construction of Fig. 5 and the assumptions previously made,

$$b'b'' = dQ = fg - fh = dv\cos\alpha - du\sin\alpha \qquad (14)$$

Substituting the values of dv and du from equations (7) and (8) in equation (14) and combining with equation (13)

$$\gamma_A = \frac{dQ}{ds} = \frac{\delta v}{\delta y}\cdot\frac{dy}{ds}\cos\alpha + \frac{\delta v}{\delta x}\cdot\frac{dx}{ds}\cos\alpha - \frac{\delta u}{\delta x}\cdot\frac{dx}{ds}\sin\alpha - \frac{\delta u}{\delta y}\cdot\frac{dy}{ds}\sin\alpha \qquad (15)$$

But from Fig. 5 $dx/ds = \cos\alpha$ and $dy/ds = \sin\alpha$, so substituting and collecting terms, we have

$$\gamma_A = \frac{dQ}{ds} = \frac{\delta v}{\delta x}\cos^2\alpha - \frac{\delta u}{\delta y}\sin^2\alpha + \left(\frac{\delta v}{\delta y} - \frac{\delta u}{\delta x}\right)\sin\alpha\cos\alpha \qquad (16)$$

To find the shear in the direction OA we can substitute (90 deg. $+\ \alpha$ for α in equation (16) if we take into account that this will be in the second quadrant where the signs of dx, $\cos\alpha$ and $\tan\alpha$ are negative. Since the shear is represented by the tangent of an angle in the second quadrant it also is negative.

$$-\gamma_B = \frac{\delta v}{\delta x}\sin^2\alpha - \frac{\delta u}{\delta y}\cos^2\alpha - \left(\frac{\delta v}{\delta y} - \frac{\delta u}{\delta x}\right)\sin\alpha\cos\alpha \qquad (17)$$

or

$$\gamma_B = \frac{\delta u}{\delta y}\cos^2\alpha - \frac{\delta v}{\delta x}\sin^2\alpha + \left(\frac{\delta v}{\delta y} - \frac{\delta u}{\delta x}\right)\sin\alpha\cos\alpha \qquad (18)$$

Adding equations (16) and (18) we obtain the value for the total shear in the directions OA and OB.

$$\gamma_{AB} = \gamma_A + \gamma_B = 2\left(\frac{\delta v}{\delta y} - \frac{\delta u}{\delta x}\right)\sin\alpha\cos\alpha + \left(\frac{\delta v}{\delta x} + \frac{\delta u}{\delta y}\right)(\cos^2\alpha - \sin^2\alpha) \qquad (19)$$

But $\dfrac{\delta v}{\delta y} = e_y$

$\dfrac{\delta u}{\delta x} = e_x$

$2\sin\alpha\cos\alpha = \sin 2\alpha$

$\cos^2\alpha - \sin^2\alpha = \cos 2\alpha$

$$\left(\frac{\delta v}{\delta x} + \frac{\delta u}{\delta y}\right) = \gamma_{xy}$$

Therefore

$$\gamma_{AB} = (e_y - e_x)\sin 2\alpha + \gamma_{xy}\cos 2\alpha \qquad (20)$$

As previously stated, when the state of stress at a point is fully determined it is seen that it has a maximum and

a minimum value in directions which are mutually perpendicular. Since equation (10) gives the unit extension as a function of the angle α with the X axis we can determine the angles which the maximum and minimum stresses make with the X axis by setting the first derivative of this expression equal to zero and solving for the roots.

$$e = e_x \cos^2\alpha + e_y \sin^2\alpha + \gamma_{xy} \sin\alpha \cos\alpha \quad \ldots\ldots (21)$$

The first derivative of e with respect to α is as follows:

$$\frac{de}{d\alpha} = (e_y - e_x) \sin 2\alpha + \gamma_{xy} \cos 2\alpha \quad \ldots\ldots (22)$$

Let $$(e_y - e_x) \sin 2\alpha + \gamma_{xy} \cos 2\alpha = 0 \quad \ldots\ldots (23)$$

Then $$\frac{\sin 2\alpha}{\cos 2\alpha} + \frac{\gamma_{xy}}{e_y - e_x} = 0 \quad \ldots\ldots (24)$$

Therefore

$$\tan 2\alpha = \frac{-\gamma_{xy}}{e_y - e_x} = \frac{\gamma_{xy}}{e_x - e_y} \text{ and } \alpha = \tfrac{1}{2} \tan^{-1}\left(\frac{\gamma_{xy}}{e_x - e_y}\right) \quad \ldots\ldots (25)$$

For a given numerical value of the tangent there must be, from trigonometric relationships, two angles 180 deg. apart and in equation (25) these angles are the two values of 2α.

This shows that there are two values for α which differ by 90 deg. and in such a case one must correspond to a maximum and the other a minimum value of e. These are the directions of the principal strains and since equation (23) is identical with the equation for shear (20) it will be understood that the shear must be zero in the direction of maximum and minimum strain.

Equations (11), (12) and (20) give the components of strain in any two mutually perpendicular directions A and B which make an angle α with the X and Y axes respectively in terms of the displacements in the X and Y directions. If we assume that X and Y are the directions of the principal strains we can derive expressions for components of strain in terms of the principal strains. Since the shear is always zero in the direction of the principal strains $\gamma_{yx} = 0$ in this case.
Under these assumptions equations (11) and (12) become

$$e_A = \tfrac{1}{2}(e_x + e_y) + \tfrac{1}{2}(e_x - e_y) \cos 2\alpha \quad \ldots\ldots (26)$$

$$e_B = \tfrac{1}{2}(e_x + e_y) - \tfrac{1}{2}(e_x - e_y) \cos 2\alpha \quad \ldots\ldots (27)$$

If we add (26) and (27) we find

$$e_A + e_B = e_x + e_y \quad \ldots\ldots (28)$$

This shows that the sum of the strains in any two mutually perpendicular directions must always equal the sum of the principal strains. Therefore, the sum of the strains in any two mutually perpendicular directions is always equal to the sum of the strains in any other two mutually perpendicular directions. It will be shown later that herein lies one of the great advantages of using rosettes with four gage lines consisting of two sets of lines mutually perpendicular.

Continuing the assumption that the principal strains are still in the direction of the X and Y axes we can determine the magnitude and direction of the maximum shear strain in terms of the principal strains which are now e_x and e_y.

The equation for total shear in any two mutually perpendicular directions A and B which make an angle α with the X and Y axes respectively in terms of displacements in the X and Y directions is given by equation (20) as follows

$$\gamma_{AB} = (e_y - e_x) \sin 2\alpha + \gamma_{xy} \cos 2\alpha$$

But in this case the shear in the direction of the principal strains (X and Y) is zero and therefore this becomes

$$\gamma_{AB} = (e_y - e_x) \sin 2\alpha \quad \ldots\ldots (29)$$

This has a maximum value when $\alpha = 45$ deg. in which case

$$\gamma_{AB} = e_y - e_x \quad \ldots\ldots (30)$$

This shows that the maximum shear strain due to the principal strains is equal to their algebraic difference and bisects the angle between them.

In the general case when the direction of the principal strains is unknown, equation (25) can be used to find the angle α which they make with the X and Y axes.

$$\tan 2\alpha = \frac{\gamma_{xy}}{e_x - e_y} \quad \ldots\ldots (31)$$

It will be more convenient if the quantity γ_{xy} can be expressed in terms of strains measured on some other pair of mutually perpendicular gage lines whose directions may be taken in general as A and B making an angle α with some other pair of mutually perpendicular gage lines.

Subtracting equation (12) from (11):

$$e_A - e_B = (e_x - e_y) \cos 2\alpha + \gamma_{xy} \sin 2\alpha \quad \ldots\ldots (32)$$

From this it is seen that when $\alpha = 45$ deg.

$$\gamma_{xy} = e_A - e_B \text{ or } \gamma_{xy} = -(e_B - e_A) \quad \ldots\ldots (33)$$

In other words, if the two sets of mutually perpendicular gage lines make an angle $\alpha = 45$ deg. with each other, the shear strain resulting from one set is equal to the difference in strains measured on the other set.
We can substitute this in equation (31) to get:

$$\tan 2\alpha = \frac{-(e_B - e_A)}{(e_x - e_y)} \quad \ldots\ldots (34)$$

Application of the Theory to a Rosette with Four Intersecting Gage Lines 45 Degrees Apart

As discussed in the preceding section, there is a marked advantage in using a rosette with the gage lines located as shown in Fig. 6. If the gage lines are designated as

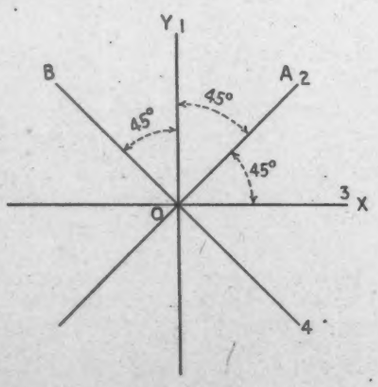


Fig. 6

shown the strains measured can be denoted by e_1, e_2, e_3 and e_4. It will be seen that e_1 and e_3 correspond to e_y and e_x and e_2 *and* e_4 to e_A and e_B, respectively.
We can now write

$$\gamma_{xy} = -(e_4 - e_2) \quad \ldots\ldots (35)$$

Keeping e_A and e_B to designate the general case of strain in any pair of mutually perpendicular directions but subsubstituting e_1, e_2, e_3 and e_4 for e_x, e_y and γ_{xy} equations (11) and (12) become

$$e_A = \tfrac{1}{2}(e_3 + e_1) + \tfrac{1}{2}(e_3 - e_1)\cos 2a - \tfrac{1}{2}(e_4 - e_2)\sin 2a \quad \ldots\ldots (36)$$

$$e_B = \tfrac{1}{2}(e_3 + e_1) - \tfrac{1}{2}(e_3 - e_1)\cos 2a + \tfrac{1}{2}(e_4 - e_2)\sin 2a \quad \ldots\ldots (37)$$

It will be seen that the first term in each of these equations involves strain measurements on only two of the four gage lines of the rosette shown in Fig. 6. It is possible, however, to bring into the computation the measurements on the other two gage lines and thus increase the accuracy of the result by averaging the errors of all four measurements.

Since $e_3 + e_1 = e_4 + e_2$ we may substitute for $\frac{1}{2}(e_3 + e_1)$ in each of these equations, the value $\frac{1}{4}(e_1 + e_2 + e_3 + e_4)$*. Since $\tan 2a = \dfrac{-(e_4 - e_2)}{(e_3 - e_1)}$ and in this case a is the angle of the principal strains, we may also substitute in equations (36) and (37) the following values for $\sin 2a$ and $\cos 2a$ which are obtainable from direct trigonometric relationships.

$$\sin 2a = \frac{-(e_4 - e_2)}{\sqrt{(e_3 - e_1)^2 + (e_4 - e_2)^2}} \quad \ldots\ldots (37a)$$

$$\cos 2a = \frac{(e_3 - e_1)}{\sqrt{(e_3 - e_1)^2 + (e_4 - e_2)^2}} \quad \ldots\ldots (37b)$$

We then have for the principal strains

$$e_A = \tfrac{1}{2}\left[\tfrac{1}{2}(e_1 + e_2 + e_3 + e_4) + \sqrt{(e_3 - e_1)^2 + (e_4 - e_2)^2}\right] \quad \ldots\ldots (38)$$

$$e_B = \tfrac{1}{2}\left[\tfrac{1}{2}(e_1 + e_2 + e_3 + e_4) - \sqrt{(e_3 - e_1)^2 + (e_4 - e_2)^2}\right] \quad \ldots\ldots (39)$$

The next step is to develop an expression for the maximum shear in terms of the strains measured on the four gage lines. The general equation for the shear strain is

$$\gamma_{AB} = (e_y - e_x)\sin 2a + \gamma_{xy}\cos 2a \quad \ldots\ldots (40)$$

If the principal strains are in the directions A and B as in the present case $\gamma_{AB} = 0$ and as has been shown, the maximum shearing strains will be at 45 deg. from A and B. Since A and B are at an angle a from X and Y the maximum shearing strains will be at $a + 45$ deg. from X and Y. Substituting $a + 45$ deg. for a in equation (40) we get

$$\gamma_{max} = (e_y - e_x)\cos 2a - \gamma_{xy}\sin 2a \quad \ldots\ldots (41)$$

But $e_y = e_1$; $e_x = e_3$; and $\gamma_{xy} = -(e_4 - e_2)$

Therefore:

$$\gamma_{max} = (e_1 - e_3)\cos 2a + (e_4 - e_2)\sin 2a \quad \ldots\ldots (42)$$

Or:

$$\gamma_{max} = -(e_3 - e_1)\cos 2a + (e_4 - e_2)\sin 2a$$

Substituting equations (37a) and (37b) in (42)

$$\gamma_{max} = \sqrt{(e_3 - e_1)^2 + (e_4 - e_2)^2} \quad \ldots\ldots (43)$$

It will be noted that this same result would be obtained by subtracting the values for e_B from e_A given in equations (38) and (39).

The Development of Equations for Combined Stress

The conversion of the strain readings into the correct values for stress in different directions at the point O in Fig. 6 will be the next step.

A unit tensile stress σ_x acting in the direction of the X axis will produce a unit elongation in this direction equal to σ_x/E, where E is the modulus of elasticity. This stress will also produce a lateral contraction which is proportional to the unit elongation in the X direction in the ratio of the constant m which is called Poisson's ratio. The contraction in the Y direction will be $-m\sigma_x/E$. Similarly a unit tensile stress σ_y acting in the direction of the Y axis will produce a unit elongation in this direction equal to σ_y/E and a unit contraction in the X direction equal to $-m\sigma_y/E$.

2. If both stresses act simultaneously, the unit elongations in the x and y directions will be

$$e_x = \frac{\sigma_x}{E} - \frac{m\sigma_y}{E} \quad \ldots\ldots (44)$$

$$e_y = \frac{\sigma_y}{E} - \frac{m\sigma_x}{E} \quad \ldots\ldots (45)$$

Rearranging, we get,

$$\sigma_x = e_x E + m\sigma_y \quad \ldots\ldots (46)$$

$$\sigma_y = e_y E + m\sigma_x \quad \ldots\ldots (47)$$

Substituting the values for σ_x and σ_y and solving for σ_x and σ_y we have,

$$\sigma_x = \frac{E}{1-m^2}(e_x + me_y) \quad \ldots\ldots (48)$$

$$\sigma_y = \frac{E}{1-m^2}(e_y + me_x) \quad \ldots\ldots (49)$$

Equations (48) and (49) may be used to determine the combined stress resulting from any two strains at right angles to each other. To determine the principal stresses, the principal strains should be substituted in these equations. The principal stresses as already mentioned are the maximum and minimum values of stress at the point O in Fig. 6 and are designated as σ_u and σ_v respectively. The maximum stress does not necessarily have the greatest numerical value but is highest in the positive sense while the minimum stress is lowest. Thus the maximum stress could be -2000 and the minimum stress -8000 lb. per sq. in.

The next step is to get equations (48) and (49) in a form in which the strains measured on the four gage lines can be substituted instead of values of e_x and e_y.

* In practice, $e_3 + e_1$ does not always equal $e_4 + e_2$ because of the human element handling the gage, unnoticed particles of dirt in the gage holes, or the slight error which is present in most gages. The value $\frac{1}{4}(e_1 + e_2 + e_3 + e_4)$ takes into consideration all four gage readings and reduces the error.

Substituting the values of the principal strains from equations (38) and (39) in equations (48) and (49) we get new expressions for the principal stresses σ_u and σ_v.

$$\sigma_u = \frac{E}{1-m^2}\left(\tfrac{1}{2}\left[\tfrac{1}{2}(e_1+e_2+e_3+e_4) + \sqrt{(e_3-e_1)^2+(e_4-e_2)^2}\right] + \frac{m}{2}\left[\tfrac{1}{2}(e_1+e_2+e_3+e_4) - \sqrt{(e_3-e_1)^2+(e_4-e_2)^2}\right]\right) \quad \ldots\ldots (50)$$

Which can be reduced to

$$\sigma_u = \frac{E}{2(1+m)}\left(\tfrac{1}{2}\frac{(1+m)}{(1-m)}(e_1+e_2+e_3+e_4) + \sqrt{(e_3-e_1)^2+(e_4-e_2)^2}\right) \ldots (51)$$

Similarly

$$\sigma_v = \frac{E}{2(1+m)}\left(\tfrac{1}{2}\frac{(1+m)}{(1-m)}(e_1+e_2+e_3+e_4) - \sqrt{(e_3-e_1)^2+(e_4-e_2)^2}\right) \ldots (52)$$

The maximum shear stress $\sigma\gamma$ is given as follows where G is the modulus of elasticity in shear and equal to $E/2(1+m)$

$$\sigma\gamma = G_s\gamma \quad \ldots\ldots (53)$$

From equation (43) the maximum shear strain is substituted in (53) to get

$$\sigma\gamma = \frac{E}{2(1+m)}\sqrt{(e_3-e_1)^2+(e_4-e_2)^2} \ldots\ldots (54)$$

It was shown that the maximum shear *strain* due to the principal strains was equal to their algebraic difference and it will now be shown that the maximum shear *stress* is equal to *one half* the algebraic difference between the principal *stresses*.
Subtract equation (52) from (51)

$$\sigma_u - \sigma_v = \frac{E}{1+m}\sqrt{(e_3-e_1)^2+(e_4-e_2)^2} \ldots (55)$$

Therefore

$$\tfrac{1}{2}(\sigma_u - \sigma_v) = \frac{E}{2(1+m)}\sqrt{(e_3-e_1)^2+(e_4-e_2)^2} = \sigma_v \ldots (56)$$

This always gives the maximum shear stress in the plane of the rosette but it will be seen that when σ_u and σ_v are of the same sign, one half of their difference will be less than the quantity $\frac{1}{2}(0 - \sigma_u)$. This means that when σ_u and σ_v are of the same sign there is a higher shear stress in the body than that in the plane of the rosette. By assuming the stress in the Z direction (perpendicular to the plane of the rosette) as zero and applying the reasoning developed above this greater "maximum" stress can be determined and will be in a plane at 45 deg. to the plane of the rosette.

The Derivation of Equations for Stress in any Direction

We will now derive the general equation for determining the stress in any direction through the point O in Fig. 6.
Using the form of equation (48)

$$\sigma_A = \frac{E}{1-m^2}(e_A + me_B) \quad \ldots\ldots (57)$$

Substituting values of e_A and e_B from equations (36) and (37) and using $\frac{1}{2}(e_1+e_2+e_3+e_4)$ in place of (e_3+e_1)

$$\sigma_A = \frac{E}{2(1+m)}\left(\frac{1+m}{2(1-m)}(e_1+e_2+e_3+e_4) + (e_3-e_1)\cos 2a - (e_4-e_2)\sin 2a\right) \ldots\ldots (58)$$

The values of e_1, e_2, e_3, and e_4 are the strains measured on gage lines *1*, *2*, *3*, and *4* of Fig. 6 by means of a strain gage. The readings are taken in dial divisions which can be converted to strain in inches per inch by the relationship $e = Kd$ where d is the number of dial divisions and K is the constant for the gage used.

The laborious task of converting each deformation from dial divisions to units of strain can be avoided by the incorporation of the constant K in equation (58) and using the notation d_1, d_2, d_3, and d_4 to designate the number of gage divisions (difference between initial and final readings). All of the readings in the rosette must of course be made with the same gage.
Equation (58) then becomes

$$\sigma_A = \frac{KE}{2(1+m)}\left(\frac{1+m}{2(1-m)}(d_1+d_2+d_3+d_4) + (d_3-d_1)\cos 2a - (d_4-d_2)\sin 2a\right) \ldots\ldots (59)$$

This equation can be used to determine the stress at any angle a measured positive counter clockwise from the X axis. There are certain directions of particular interest for which it will be worth while to derive special equations for determining the stress; these are the directions of the gage lines in the rosette shown in Fig. 6. For gage line *1* the augle $a = +90$ deg. and $2a = 180$ deg.

$$\sigma_1 = \frac{KE}{2(1+m)}\left(\frac{1+m}{2(1-m)}(d_1+d_2+d_3+d_4) - (d_3-d_1)\right) \ldots (60)$$

For gage line *2* the angle $a = +45$ deg. and $2a = 90$ deg.

$$\sigma_2 = \frac{KE}{2(1+m)}\left(\frac{1+m}{2(1-m)}(d_1+d_2+d_3+d_4) - (d_4-d_2)\right) \ldots (61)$$

For gage line *3* the angle $\alpha = 0$

$$\sigma_3 = \frac{KE}{2(1+m)}\left(\frac{1+m}{2(1-m)}(d_1+d_2+d_3+d_4)+(d_3-d_1)\right) \quad (62)$$

For gage line *4* the angle $\alpha = 135$ deg. and $2\alpha = 270$ deg.

$$\sigma_4 = \frac{KE}{2(1+m)}\left(\frac{1+m}{2(1-m)}(d+d_2+d_3+d_4)+(d_4-d_2)\right) \quad (63)$$

Determination of the Direction of the Maximum Stress

From equation (34) we can derive from the measured deformations on the four gage lines an expression which enables us to determine the angle a which the maximum stress σ_u makes with the X axis.
This equation is

$$\tan 2a = \frac{-(e_3-e_4)}{(e_x-e_y)}$$

The right hand side of this equation is a ratio of differences in strains which are proportional to corresponding dial divisions (difference between initial and final readings). Therefore we can write

$$\tan 2a = \frac{-(d_4-d_2)}{(d_3-d_1)} = \frac{-b}{a} \quad \ldots\ldots (64)$$

The angle α is measured positive counter-clockwise from the X axis (gage line *3*) toward the maximum and while the numerical value of the tangent does not depend on the algebraic signs of the quantities on the right hand side of the equation it is necessary to take the signs into consideration in order to locate the angle. Fig. 7 will be of considerable help in this regard. The signs of the numerator and denominator are indicated on rectangular axes and the angle (2α) will fall in the quadrant corresponding to the signs of these two terms. The location of the angle α can then be readily determined.

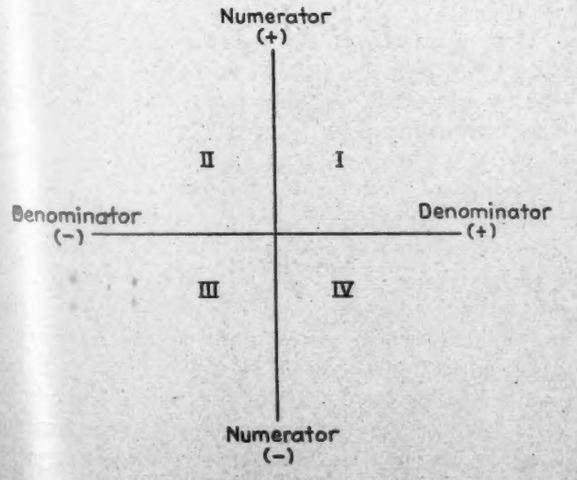


Fig. 7

Working Formulas for Computing all Stresses in Steel

The equations up to this point are all general in that they can be applied to any elastic material by substitution of the proper elastic constants. When a large amount of work is to be done on one type of material for which these values are essentially unchanged it is advantageous to incorporate the elastic constants in the working equations. For high carbon steel the following have been extensively used and are as good as the experimental data can furnish.

$$E = 29 \times 10^6 \text{ lb. per sq. in.}$$

$$m = 0.3$$

Also let $(d_1 + d_2 + d_3 + d_4) = \Sigma$, and $(d_3 - d_1) = a$, and $(d_4 - d_2) = b$ and $(a^2 + b^2) = c$.

If these quantities a, b, and c, together with the above numerical values for E and m are substituted in equations (51), (52), (60), (61), (62), and (63) it is found that considerable simplification is obtained. For example

$$\frac{KE}{2(1+m)} = 11.15 \times 10^6 K$$

and

$$\frac{1+m}{2(1-m)} = 0.93$$

This gives the following working equations.

$$\sigma_{max} = 11.15 \times 10^6 K\ [0.93\Sigma + c] \quad \ldots\ldots (65)$$

$$\sigma_{min} = 11.15 \times 10^6 K\ [0.93\Sigma - c] \quad \ldots\ldots (66)$$

$$\sigma_1 = 11.15 \times 10^6 K\ [0.93\Sigma - a] \quad \ldots\ldots (67)$$

$$\sigma_2 = 11.15 \times 10^6 K\ [0.93\Sigma - b] \quad \ldots\ldots (68)$$

$$\sigma_3 = 11.15 \times 10^6 K\ [0.93\Sigma + a] \quad \ldots\ldots (69)$$

$$\sigma_4 = 11.15 \times 10^6 K\ [0.93\Sigma + b] \quad \ldots\ldots (70)$$

Similar substitution in equation (59) gives the following equation for finding the stress in any direction α, measured positive counter-clockwise from the X axis (gage line *3*).

$$\sigma a = 11.15 \times 10^6 K\ [0.93 + a \cos 2a - b \sin 2a] \quad \ldots\ldots (71)$$

The constant K will vary from gage to gage but when a large amount of work is done with one gage this constant can be incorporated in the above equations as a fixed value (in which case let $11.15 \times 10^6 K = K^1$).
The maximum shearing stress

$\sigma\gamma = \frac{1}{2}(\sigma_{max} - \sigma_{min})$ when σ_{max} and σ_{min} are of opposite sign
$\sigma_\gamma = \frac{1}{2}\sigma_{max}$ or $\frac{1}{2}\sigma_{min}$ when they are of the same sign, whichever gives larger numerical value.

The angle of the principal stress is given by

$$\tan 2a = \frac{-(d_4-d_2)}{(d_3-d_1)} = \frac{-b}{a} \text{ according to Fig. 7.}$$

(To be continued)

EDITORIALS

Our Prize Competition

Don't overlook the fact that the *Railway Mechanical Engineer* competition for the best articles on ways and means of improving mechanical department operations or practices to increase production and secure a larger use from the equipment and facilities, announced in our October number, will close on January 15, 1942. We are delighted with the wide interest that has been shown in the announcement of this competition. Certainly there never was a time when it was more important to eliminate waste and lost motion and speed up the productive capacity of our transportation system. Mail your article as early as possible and do not run the risk of its not reaching us by January 15.

A Blow to Technical Progress

In this issue is an article describing a box-car design recently developed by the Chicago, Milwaukee, St. Paul & Pacific, from which 500 cars have been built. The car body is a completely welded structure and in its design are many unique features. This design is typical of the developments which have constantly been taking place on American railroads under our system of private enterprise which offers the minimum of restriction to the exercise of initiative and ingenuity on the part of every group in the field.

Another article in this issue records the announcement of the Association of American Railroads of its proposed drastic limitation of the number of car designs from which orders will be placed by the railroads for general service during the present emergency. The announced purpose of this proposal is to comply with the desire of the O. P. M. so that the latter, in turn, may be induced to be generous with the railroads and the car builders in their allocation of materials needed to effect the proposed increase in freight-car ownership to 1,800,000 by October 1, 1942.

The conflict presented by these two articles is typical of the general conflict which must be faced by every democracy in time of peril. The strength of a democracy is measured by the willingness of its citizens to forego the exercise of cherished rights and privileges in the face of outside peril, and by their ability to regain the exercise of those rights and privileges when the emergency is over.

A program of standardization such as that proposed by the A. A. R. will simplify the entire problem of production and allocation of steel, which plays so important a part in meeting the rapidly expanding demands of our defense program. It will also simplify production problems of the car builders. To this there will probably be little dissent. But there will be much less complete agreement that the particular designs proposed are the best which could be chosen. In defense of them it must be said that no set of standards which are to be accepted without compulsion can be much higher than the least common denominator in the state of the art.

The irony of the situation in which the raliroads find themselves is that much of the equipment that will be purchased to meet the emergency will be far on its way to becoming obsolete before it moves a mile. If the cars built now under such a program could be disposed of when the emergency is over, their effects would be much less disturbing. But they will act like balls and chains on the progress of the railroads, preventing, for the better part of another generation, their benefiting from materials and methods of construction available now.

Get What You Need While You Can

Every railroad officer and supervisor who has any influence whatsoever upon the selection and purchase of equipment used in the maintenance of motive power and rolling stock knows from long experience that the best time to get new equipment is when his road is "in the black" and the management is receptive to requests for the necessary expenditures. When traffic falls off, and with it, earnings, the natural inclination of management is to curtail expenses, particularly expenditures for new equipment the pressing need for which has passed.

There are, under present conditions, several rather negative attitudes on the part of railroad men concerning the acquisition of shop equipment which indicate that the problem is not being studied as carefully as it should be. There are those who assume—erroneously in many cases—that because the machine tool and shop equipment manufacturers are loaded up with defense orders it wouldn't be any use of thinking about buying anything because it couldn't be delivered anyway. So why bother? Another attitude is that under the priorities system—which seems to be a deep mystery to many railroad men—the O. P. M. wouldn't let a railroad have a machine or a tool if it needed it the worst way. Both of these, and many other, similar assumptions are wrong in so far as many of the things the railroad shops need are concerned.

Of all of the negative thinking on the part of railroad men that by those who fail to recognize that the railroads are in themselves a defense industry, vital to the success of the entire defense program, is the most short-sighted of all.

Certainly, many of the machine tools that a railroad uses are also needed by defense industries engaged directly in the production of munitions for the Army and the Navy. It is but right that these needs should be met as quickly as possible and the established government agencies are set up to see that this is done. But, there are many other types of equipment not as drastically needed by defense industries on which railroads, or industry, can get surprisingly satisfactory deliveries —for these times.

These things being true we raise the question: "How do you know what you can or can not get if you haven't made any efforts to get it?" To the man who assumes that the manufacturer can not deliver: "How can you be sure what and when he can deliver if you make no effort to find out?" To the man who assumes that a railroad cannot get a priority rating high enough to be of any value we say: "How do you know what rating you can get if you haven't made formal application for a rating?" Information that comes to us day by day offers convincing evidence that many people in responsible positions in the railroad industry are not too well posted on ways and means of getting the things that are badly needed to maintain the high standard of rail transportation which has so far enabled the industry to break many all-time records.

For almost 10 years the railroads did very little in the way of a program of shop modernization with the result that when the present emergency stimulated rail traffic and started putting the pressure on the shops the equipment in most of these shops, judged by the average age of all shop units, had reached an all-time low point in the scale of obsolescence. It is true that many shop tools have enjoyed a service life in years somewhat beyond that reasonably to be expected in other industries, mostly because the usage, in machine-hours, for example, in the railroad industry has always been much lower than in many other industries. That is why a 30-year-old machine may, in some cases, be in reasonably good condition, from a mechanical standpoint, and still be obsolete from a production standpoint because it can't compete with a modern machine.

A next important factor is that for the past year the shops have been working under pressure and machine tools and other shop equipment have been in service one to three full shifts each day. At the present rate of use more of the service life of many shop units will have been used up in the current two-year period than would ordinarily be used in from six to eight such years as 1935 or 1936. All of this points to the fact that railroad shops are going to need new tools and shop equipment in from six months to two years from now more than they have ever needed them in the past 20 years if for no better reason than that they are wearing out already obsolete equipment at a faster rate than at any time in that period.

There may be those who feel that because deliveries are slow and prices are higher this is not the time to order the equipment that will soon be needed but we would like to pay our respects to the railway officer whose present practice shows that he faces a situation realistically. His decision is that he will now place orders for needed equipment under the most favorable terms possible with the full knowledge, born of years of railroad experience, that if he waits until prices are lower and deliveries are shorter it will probably be because the time will have come when business has fallen off and, to use his own words, "Then try and get the management to approve an A. F. E.! No, I'll take mine now while the getting is good." This, it seems to us, is a good policy for railroad men to adopt and for manufacturers to recognize. Early reports of shop equipment purchased during 1941 indicate that this particular officer was not alone in the application of such a policy.

Free Smokes For Broken Records

According to "Steel in Defense," a monthly leaflet published by the American Iron and Steel Institute, one steel mill in the Pittsburgh district has established the practice of passing the cigar box around each time any of its mill crews or departments sets a new production record. During June, July and August, so many new records were hung up, mostly on defense orders, that the company had to deal out 40,925 cigars, 16,450 packs of cigarettes, 500 stogies, and 192 packs of chewing tobacco. Non-smokers and non-chewers among the men divided up 339 lb. of candy.

The purpose of mentioning this practice of one of the steel mills is not necessarily to suggest that railroads can or should adopt the idea and distribute tobacco in one form or another as an incentive for breaking production records at railway locomotive shops, car shops and engine terminals. Vital as is the need for steel today, however, is it not a fact that rail transportation occupies a position of even greater importance in our scheme of industrial production and national defense than does the manufacture of any single commodity? Assuming that this question is answered in the affirmative, as indeed it must be, is it not highly essential to increase the efficiency and stimulate production in every department of railway operation, including particularly the mechanical department which has the important responsibility of keeping cars and locomotives in condition to handle the nation's traffic safely and satisfactorily at all times?

Railway equipment-maintenance practices are pretty well standardized and doubtless some shops and enginehouses could be found throughout the country which have not benefited by the installation of a single new machine tool, or possibly even a new idea, in several

years. It may be said with equal certainty that no shop or enginehouse has been so successful in securing improved machinery and installing new methods that no further improvement is possible. Obviously, the present would be an excellent time for railway mechanical officers and shop supervisors to take an inventory of their maintenance facilities as regards both tools and personnel and see what can be done to improve both. One constructive step would apparently be to stimulate healthy competition between individual shops on the same railway to the fullest extent practicable and also to set up in each shop and sub-department measuring sticks by which its weekly or monthly performance can be checked with previous records, weak points in the equipment or organization discovered and more or less continuous improvement secured. Fortunately, well-developed campaigns of this nature are already producing good results in the progressive mechanical departments of a number of railways, so general information regarding what needs to be done and what results may be expected is not difficult to obtain.

As pointed out in these columns many times before, the importance of the human reactions in any program of shop improvement can hardly be overestimated. In considering plans for increased output, reduced locomotive or car days in shop and reduced unit repair costs, it is obvious that every means should be exhausted to attract the interest of the shop men who actually do the work and give them definite incentives, not necessarily to work harder, but to eliminate waste effort, use their heads to save their backs, develop all possible short cuts which can be put in effect without sacrifice of quality workmanship and increase their individual and group efficiencies.

The charge is often made with some degree of justification that railway shop operations are pretty much "cut and dried," often dirty and seldom mentally stimulating to the men in overalls who do essentially the same kind of work, day after day. Admitting the essential difficulty of the job, why would it not be possible to visualize and dramatize such operations as the fitting of locomotive driving rods, washing out boilers, or repairing car trucks and show how, without this work, it would be impossible to feed or clothe the nation, or even move the guns, armament and troops needed for its defense? Railway men are not less aggressive, less progressive or less patriotic citizens than those employed in steel mills, once their imaginations are aroused, and it is definitely the responsibility of railway mechanical managements to develop and seize upon every new idea which promises to impress equipment maintenance forces with the vital importance of their work, especially in the present emergency, and encourages them to greater individual efforts in its performance.

If "smokes" are needed to put railway shop and enginehouse forces on their toes, smokes they should have! If some other idea apparently will produce better results, it should be developed and put into effect without delay.

Why Were They Honored?

A most unusual series of events took place early last June, when three universities in widely separated parts of our nation, bestowed honorary degrees upon the heads of three railway mechanical departments.

On June 6, George McCormick, general superintendent motive power of the Southern Pacific Company, was given the honorary degree of Doctor of Engineering by his Alma Mater, Texas Agricultural and Mechanical College. Three days later Frederick W. Hankins, assistant vice-president of the Pennsylvania Railroad, was given the honorary degree of Doctor of Science by Bucknell University. On June 11, K. F. Nystrom, mechanical assistant to the chief operating officer of the Chicago, Milwaukee, St. Paul & Pacific, was awarded the honorary degree of Doctor of Engineering by Marquette University.

Such things do not just happen. Degrees of this kind are not distributed carelessly. It is quite unusual, also, for such honors to be bestowed upon railway mechanical department officers. Why were these three men selected? What qualities do they possess; what have they accomplished to merit this distinction?

The *Railway Mechanical Engineer* will attempt to answer these questions in a series of three rather intimate articles about these men. The first one, in the order of the date of the Commencement exercises, will appear in our next, or January, 1942, issue, and the other two in consecutive issues. We know that they will be an inspiration to all of the officers of the mechanical department, and particularly to the younger men who are starting in at the bottom of the ladder and are striving to improve themselves, so that they may qualify for greater recognition and advancement in the days to come.

New Books

MANUAL OF ORDINANCES AND REQUIREMENTS IN THE INTEREST OF AIR POLLUTION, SMOKE PREVENTION AND FUEL COMBUSTION. *176 pages, 6 in. by 9 in. Bound in paper. Official publication of the Smoke Prevention Association of America, Inc., 139 North Clark Street, Chicago, Ill. Price, Sixty Cents.*

This manual includes information for those interested in eliminating smoke and air pollution in our towns and cities. It includes a model smoke abatement ordinance. The greater part of the book is devoted to the proceedings of the thirty-fifth annual convention of the Smoke Prevention Association. Of special interest to railroaders are papers on Cyclone and Anderson Front Ends for Locomotives—Spark Arresters Without Netting by Leslie R. Pyle, Locomotive Firebox Company; Railroad Smoke Problems and Stoker Firing by Samuel A. Dickson, fuel supervisor, Alton Railroad; Grate Design and Its Influence on the Burning of Fuel and on the Abatement of Smoke by J. W. Hulson, president, Hulson Grate Company; and Abating Locomotive Smoke in Chicago by A. Deutch and S. Radner.

THE READER'S PAGE

Standard Locomotives For American Railways

To the Editor:

Standard locomotives have long been a favorite theme of those who believe that regimentation is synonymous with efficiency. Projects for the complete standardization of steam locomotives can be traced back as far as 1840. While the earliest schemes were put into effect in England, three other countries, the United States, Germany and British India have engaged in the practice most extensively.

If the benefits sought from the standardization of locomotives are to be obtained, it is obvious that the standard designs must remain essentially unaltered during a considerable period of time. A study of locomotive history will reveal that the normal progress of railway mechanical engineering has permitted extremely few standardization programs to survive more than six or seven years without drastic modification. In some instances, standard locomotives have become obsolete within five years after completion of the first drawings. Sooner or later, those railroads which have adhered most rigidly to standardized motive power have found that their locomotive stock has failed to keep pace with that of other companies who have pursued a free course.

Present-day advocates of standardization place great emphasis upon results achieved in Germany during recent years. The program in effect in that country since 1925 is the culmination of a series of standardization schemes, the first of which was adopted in Prussia in 1876. The existence of these earlier schemes did not prevent the accumulation of 210 different classes of locomotives on the German railways by 1920. The present work has been carried out with characteristic Teutonic thoroughness and, incidentally, with much blaring of trumpets. Like everything else so far promoted by the Third Reich, it is an "unqualified success."

But if one studies the German locomotives very closely, he soon discovers an unusual amount of elasticity in the present standardization program. A half dozen new types have already been added to the sixteen originally planned for use on the standard gauge lines. The details of individual types have also been considerably altered from time to time. Consider, for example, the 4-6-2 type fast passenger locomotives. Between 1925 and 1938, no less than twelve different groups of "Pacific" type locomotives were built for the Reichsbahn. Each group consisted of anywhere from ten to one hundred locomotives. Most of them bore a close superficial resemblance to one another, but there were fundamental differences in cylinder arrangement and internal boiler design, and many vital parts were not interchangeable. Few will need to be reminded that maximum interchangeability of parts is the keystone of any standardization plan.

Whether or not standard locomotives should be generally adopted in America would appear to be a relatively simple problem. Only one question need be asked. Has the orthodox steam locomotive finally reached the point where no further improvement in design or construction is possible? If the answer is in the affirmative, then the time is ripe for a comprehensive standardization program. If, on the other hand, it is agreed that the steam locomotive has not yet attained finality, then it is still possible to correct a motive power situation which has been aptly described as a "riot of individuality," without simultaneously stifling the march of progress. The much discussed consolidation of American railroads into a small number of large systems, each with its own independent, able and wide-awake mechanical department, would result in the purchase of locomotives in far larger groups than at present, with a consequent ultimate reduction in the number of designs in service throughout the country. At the same time, the element of competition which has assisted in the development of the best motive power in the world would be fully retained.

The foregoing discussion has been confined entirely to the steam locomotive. Other forms of motive power have been purposely omitted, because it is felt that no informed individual would seriously propose the standardization of either electric or Diesel locomotives at this stage of their evolution.

W. T. Hoecker.

First Bead in Vertical Vee — A Difference of Opinion

To the Editor:

The November issue of the *Railway Mechanical Engineer* has on page 491 an answer to a question about the first bead in a vertical vee weld using a coated electrode.

It is my belief that the answer is very misleading. There is no reason, except lack of knowledge about how to manipulate, why the first bead in such a weld should look like a "bunch of grapes" or have laps and slag inclusions. It is perfectly possible to make a completely sound weld "vertical-up" with a flat smooth face by using the proper electrode and procedure.

A "vertical-down" bead will usually have a very good appearance but if it does not have holes it will be unusual; but what is worse, it will not have proper penetration. Even a skillful welder who can make an excellent "vertical-up" bead will not obtain comparable penetration in a down bead. We feel that penetration is extremely important and this is especially true of the first bead.

We have made a good many tests in our laboratory with "vertical-down" beads using many types of electrodes and we have obtained neither satisfactory penetration nor soundness. It is practically impossible to eliminate pinholes in this procedure.

The only reason for commenting on this item is that we think unsatisfactory welds will result from the use of "vertical-down" beads. Practices that lead to unsatisfactory results may lead to more restrictions on welding and there are already too many restrictions that cannot be justified.

I would suggest that the one who asked for the information have his foreman request the company furnishing the electrode he is using to send an instructor to show him how to make a "vertical-up" bead. All electrode manufacturers have such men available and normally are anxious to cooperate.

L. E. Grant,
Metallurgical and welding engineer
C. M. St. P. & P.

Improved Method for Checking

Alignment of Running Gear*

Part I†

THE alignment of driving wheels, engine trucks and trailer trucks is one of the most important functions of the back shop and has a profound effect on the availability and maintenance cost of the locomotive throughout its life. These parts are basic elements of the locomotive and its successful operation is dependent upon their proper adjustment and condition.

Improper alignment results in many chronic defects which increase the time the locomotive is held out of service for repairs and which increase maintenance cost. Some of the most common defects resulting directly from improper alignment are: Locomotive does not track evenly and runs to one side causing uneven wear of tires and wheel flanges; chronic overheating of main journals, crank-pin bearings and truck journals; excessive and uneven wear of hub liners, hub faces and journal bearings and excessive wear on crank pins and rod bushings.

There are other defects which may result indirectly from improper alignment for which the causes are not always readily apparent and are often difficult to determine.

The main frames are the foundation of the locomotive and it is extremely important that they be square within reasonable limits and that any slight irregularities be known and compensated for in the alignment of the drivers and trucks. Such conditions can be checked and corrections made only in the backshop where tools, facilities and time are available for performing the work in a proper and accurate manner.

There are several methods in use for checking alignment and squaring frames, practically all of which have some good points. The practice described here includes the best features of the several methods, is applicable to all types of modern locomotives and is as simple as possible consistent with producing accurate results.

Method of Procedure

The work of aligning driving wheels, engine and trailer trucks and laying off shoes and wedges may be classified into eight principal operations as follows: square and check the main frames for alignment; check the alignment of cylinders in relation to main frames; locate and square main centers; lay off shoes and wedges; check driver lateral to determine the thickness of the hub liners on the boxes; square and check the alignment of the engine truck; square and check the alignment of the trailer truck and tram the locomotive after the drivers are applied and make final check of alignment of axles, wheel centers and tires.

If these operations are correctly performed and the necessary corrections made for irregularities found, the locomotive will be properly lined and squared when it leaves the shop and should be free of the troubles resulting from improper alignment.

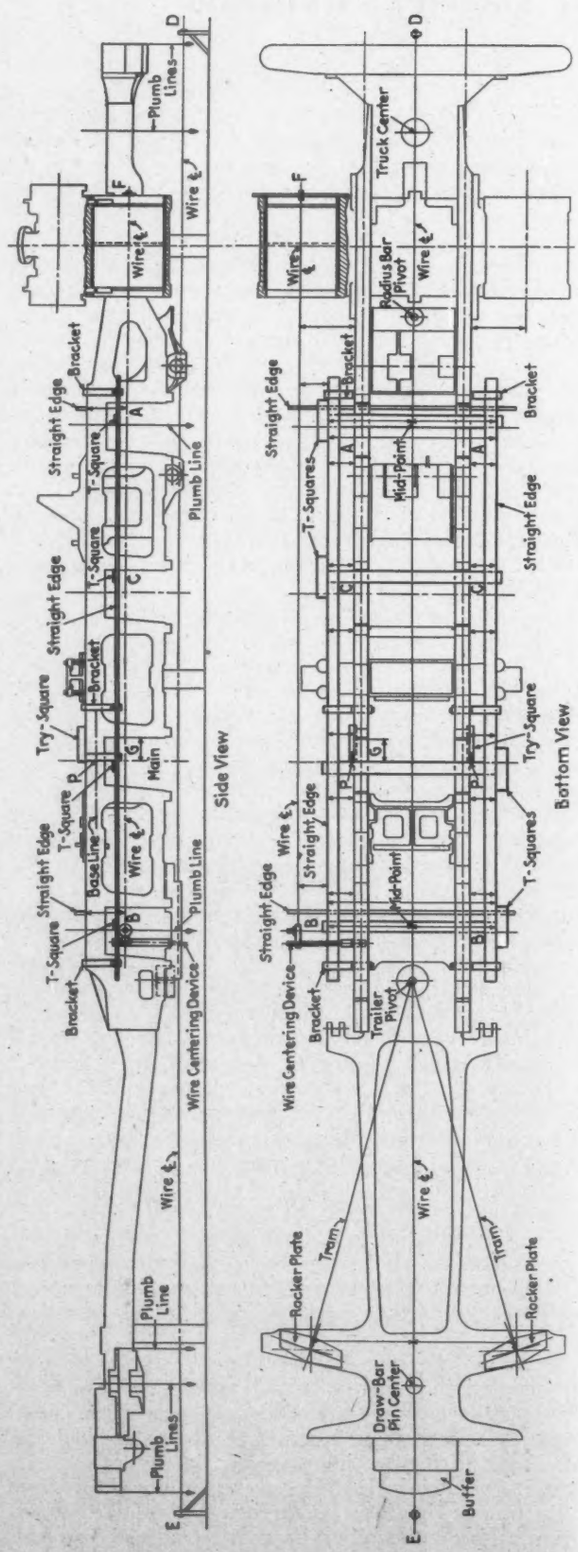


Fig. 1—Arrangement of the various tools used in checking locomotive running gear

* Abstract of a report presented at the annual meeting of the Locomotive Maintenance Officers' Association at the Hotel Sherman, Chicago, September 23-24, 1941.

† Part II will appear in the January issue.

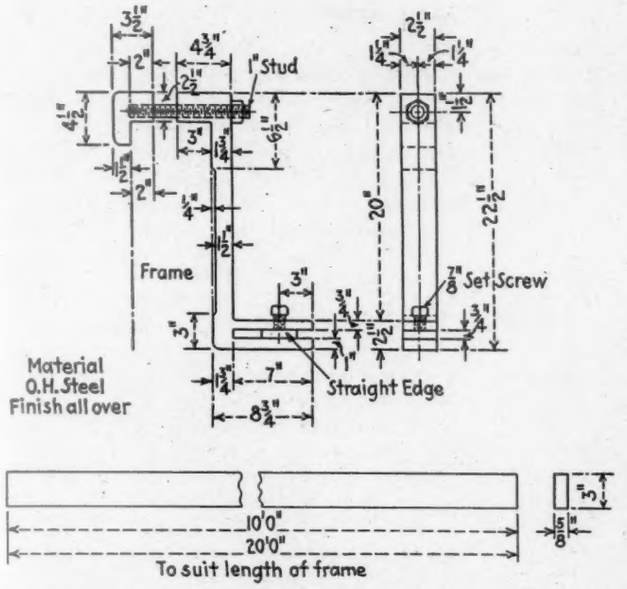


Fig. 2—Bracket for supporting the straight edge and a detail of the long straight edge

side faces of that member, and is designed to allow lateral adjustment of the straight edge.

The straight edges are set parallel to the frame on each side by means of spacer, or gauge, blocks at points *A* and *B* (Fig. 1) and are then clamped in the brackets. Next, measure distance between the outside edges of the two straight edges at *A* and *B*. If the distances are equal the frames are parallel.

If these distances are not equal, set each straight edge in at the wide end, an amount equal to one half the difference, so that the distances are equal. The straight edges are then parallel and are parallel to the mean center line of the frames. This operation is especially important.

Measure the distance from the outside edge of each straight edge to the outside face of the fame at each pedestal jaw. If all of these measurements on one side are equal, the frame is straight on that side. If they are not equal the frame is bowed, or sprung. These measurements are used to determine the thickness of the driving box hub liners required to obtain the proper alignment of driving wheels.

To check the frames for squareness, set the head of a long T-square against the outside edge of one straight edge with the blade extending through the pedestal to

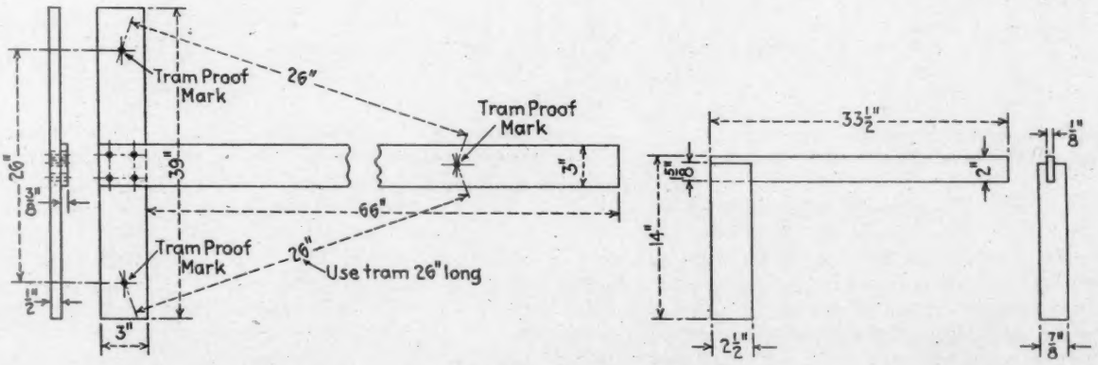


Fig. 3—T-square and try-square

Square and Checking Main Frames

The proper basis to work from in checking and aligning the main frames is the mean center line of the frames themselves since they are the foundation of the locomotive and contain the rigid wheel base. This basis is more satisfactory than others, including the fishtail tram or center lines through cylinders extended to the rear pedestals, as, with modern locomotives having a long wheel base and heavy frames, the chances of error are less and the results obtained are therefore more accurate.

Preparatory to checking, the main frames should be assembled complete with cylinders, cross-ties, center casting, rear-end cradle, etc. They should be set level and supported in such a manner that the pedestal jaws are not sprung when the pedestal binders are removed. All frame surfaces at the pedestals should be clean and smooth as these are the primary working surfaces from which the check is made. The pedestal binders should then be fitted and applied.

The checking should be done from two long straight edges set parallel to the frames on each side as shown in Fig. 1. They should be supported by suitable brackets in sufficient number to prevent sagging. A detail of the bracket used is shown in Fig. 2. It is clamped to the top rail of the frame, bearing on the top and out-

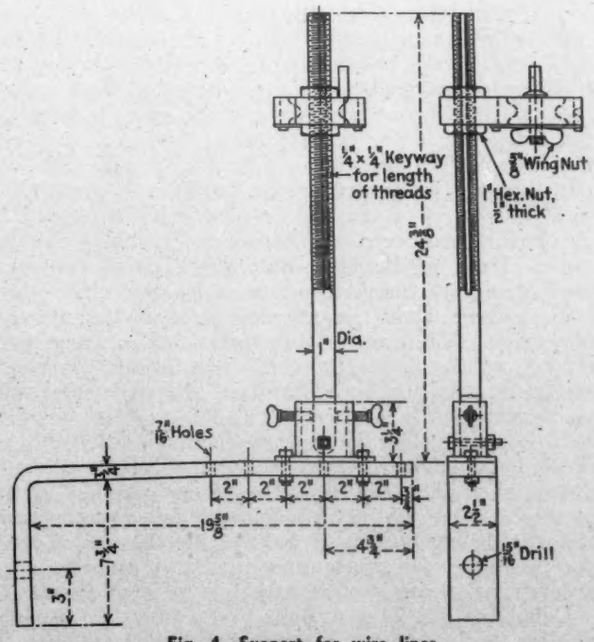


Fig. 4—Support for wire lines

the straight edge on the opposite side, as shown at *C* (Fig. 1). Move the T-square against the faces of the pedestal jaws. The frames are square if these faces bear evenly against the edge of the T-square across their entire width. Reverse the T-square and re-check. The check should be made at each pedestal.

The alignment of the engine-truck center, radius-bar pivot, trailer-truck pivot, trailer-truck rocker plates, draw-bar pin hole and the rear buffer casting should be checked by means of a wire, *D-E*, shown in the side view of Fig. 1, stretched taut below the frames, on the center line. The wire should be located on the center line of the frames midway between the outside edges of the straight edges at *A* and *B*. The location of this wire is accomplished by means of a plumb line from a T-square across the straight edges at *A* and *B*. The plumb line is set to the mid-point on the T-square, extending downward to the wire. In this case, particular care should be taken to see that the frames are cross leveled and that the T-square, across the straight edges is level.

The alignment of the various points mentioned above should then be checked with reference to the wire center line by means of plumb lines. This will also provide for checking the alignment of the front extension and the rear frame cradle. If the centers of these points, such as the engine- and trailer-truck centers, draw-bar pin hole, rear buffer casting, etc., coincide closely with the wire center line, they are in correct alignment. If not, they are off center or the frames are sprung.

The location of the trailer rocker plates should be checked by marking their centers and checking the distance to the wire center line, which should be equal on both sides. Check the distance between the rocker-plate centers which should closely equal the drawing dimension. The tram distance between the trailer pivot center and the centers of the rocker plates, as shown, should be equal on both sides and should be the same as the drawing dimension.

It will be noted that, in the method described, all checking is done with reference to the outside edges of the long straight edges which are set parallel to the mean center line of the main frame. This common basis for all checking operations reduces the chances of error and provides more accurate results than is possible when different bases are used for the various operations.

Details of the long straight edges and the T-square used in this operation are shown in Fig. 2 and Fig. 3.

Checking Alignment of Cylinders

It is important that the cylinders be in proper alignment relative to the main frames. The center lines of the cylinders should be reasonably parallel to the center line of the frames and the correct distance therefrom.

This should be checked by running a wire center line, *F-B*, (bottom view, Fig. 1) through the bore of the cylinder and extending to the rear pedestal. Attachment at the rear pedestal should be made by means of a wire centering device, the detail of which is shown in Fig. 4, clamped to the binder.

The lateral alignment of the cylinder bore is checked by measuring the distance of the wire center line from the outside edge of the long straight edges at *A* and *B* and from the outside face of the frame at *A*. The former distance should be equal at both locations and the latter should agree with drawing dimensions within reasonable limits. It is important that the cylinder center lines be parallel to the straight edges which are parallel to the center line of the frames, as the straight edges are used in locating and squaring the main centers.

The vertical alignment of the cylinder bore is checked by placing straight edges across the top of the frames at *A* and *B* and measuring the distance between the lower edge of the straight edge and the wire center line at each location. These distances should be nearly equal and should also agree with the drawing dimension.

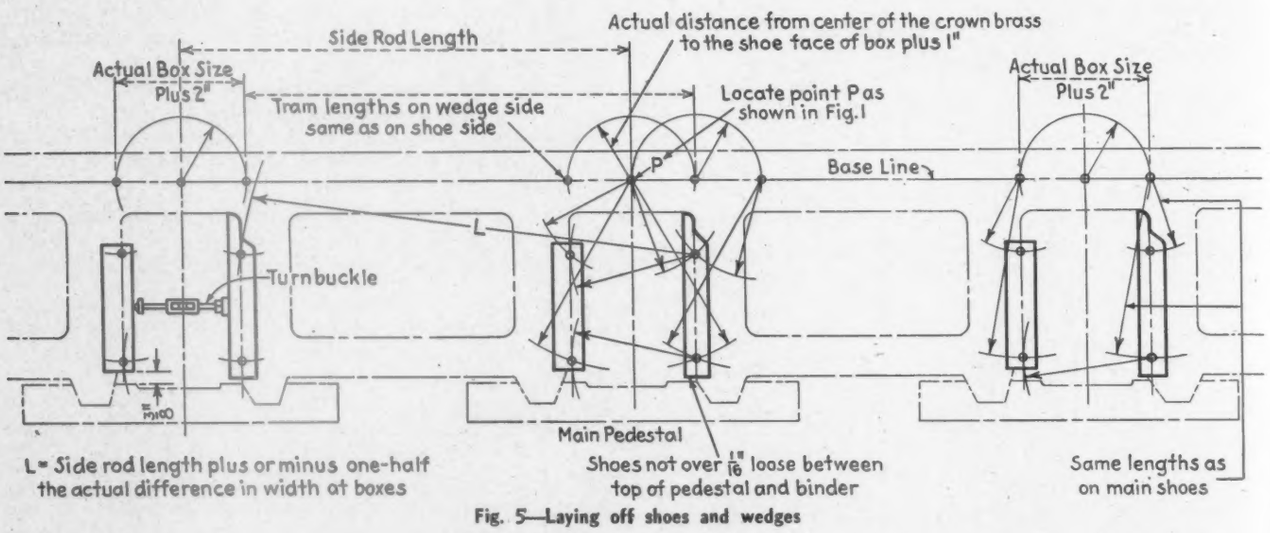

Side Rod Length
Actual distance from center of the crown brass to the shoe face of box plus 1"
Actual Box Size Plus 2"
Tram lengths on wedge side same as on shoe side
Locate point P as shown in Fig. 1
Actual Box Size Plus 2"
Base Line
P
L
Turnbuckle
Main Pedestal
L = Side rod length plus or minus one-half the actual difference in width at boxes
Shoes not over 1/16" loose between top of pedestal and binder
Same lengths as on main shoes

Fig. 5—Laying off shoes and wedges

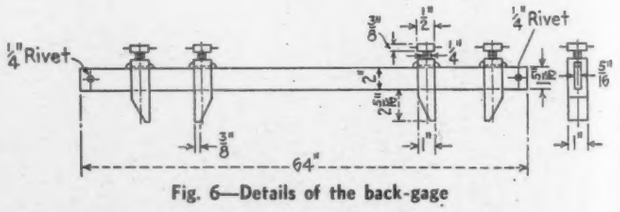


Fig. 6—Details of the back-gage

Locating and Squaring Main Centers

The main centers are the points from which all other driving box centers are located and from which the shoes and wedges are laid off. This controls the alignment of the driving wheels. Therefore, the proper location of the main centers and their squaring with the main frames and cylinder center lines is very important.

To perform this operation, set a T-square across the long straight edges, through the main pedestals, as shown

at *G* (Fig. 1). The front edge of the T-square should be set back from the shoe face of the pedestal a distance equal to the thickness of the shoe plus one half the width of the driving box, as shown on the box drawing.

If the frames are square, and with the head of the T-square set tight against the outside edge of the long straight edge, the distance from the front edge of the T-square to the pedestal face will be the same on both sides of the frame. If the frames are not square and the T-square is set to the correct distance from the pedestal face on one side, the distance on the opposite side will not be equal. In this case, move the T-square forward or back, as the case may be, one half the difference, so that this distance on both sides is equal, and clamp the T-square to the long straight edges with C-clamps.

Scribe a base line on the outside of the frame above the main pedestal a convenient distance from the top, as shown in Fig. 1. Set a try-square (shown at the right in Fig. 3) with one leg on top of the frame and the other leg extending downward with one edge against the front edge of the T-square. Where this edge of the try-square crosses the base line, prick-punch a point *P*. This is the correct location of the vertical center line of the main boxes, properly squared with the mean center line of the main frames and cylinders. Reverse the T-square and re-check.

Laying Off Shoes and Wedges

In laying off shoes and wedges the vertical center lines of the driving boxes, other than the main, are located from the main centers *P* (Fig. 1), which have previously been properly located and squared. This is done by first extending the base line through point *P* to all pedestals and then locating all other centers from *P* by means of trams set to actual side-rod length, which center points are then marked on the base line with a prick-punch, as shown in Fig. 5.

Apply the shoes and wedges solidly against the pedestal faces, holding them in place by means of turnbuckles. Then lay off main shoes and wedges from the main center point *P*, as shown in Fig. 5. When this has been done the other shoes and wedges are laid off from the centers marked on the base line and from the main shoe and wedge points as shown.

The points marked on the outside faces of the shoes and wedges should be transferred to the inside faces by a back gage, the details of which are shown in Fig. 6.

After machining, apply all shoes and wedges to the pedestals to check the box fit and see that the shoe and wedge faces are parallel and in line with those of the opposite side of the frame.

Questions and Answers On Welding Practices

(The material in this department is for the assistance of those who are interested in, or wish help on problems relating to welding practices as applied to locomotive and car maintenance. The department is open to any person who cares to submit problems for solution. All communications should bear the name and address of the writer, whose identity will not be disclosed when request is made to that effect.)

Applying Heavy Deposits On First Pass

Q.—When brazing pistons, link blocks and many other parts that require a depth of bronze deposit I find I have to make several passes to reach the desired thickness. Is there a way to gain this thickness on the first pass?

A.—The easiest way to acquire a heavy deposit of bronze on such parts is to place the part to be brazed in such a manner that it presents an angle or side-hill effect to the welder—about a 45-deg. angle is sufficient. When brazing link blocks or similar parts that are to be laid out after brazing, it is advantageous to have a square edge on the bronze deposit. Brazing a ½-in. wide strip up both sides of the part first will aid in doing this and also makes it simpler to fill in the center to the desired depth.

Rebuilding Brake Beam Ends

Q.—It is standard practice in many shops to rebuild the ends of brake beams, brake hangers, and other worn parts. Can this be done so that subsequent machining or filing is not needed?

A.—Brake hangers, brake beams and other similar parts can be rebuilt so that no machining is needed. Before attempting these operations secure a bushing similar to the one that will be used on the part. There is usually a shoulder worn on brake-hanger posts and the ends of the brake beams that will give the welder a fair idea of the amount of metal needed to bring the part back to size. When an area some 2 in. sq. is welded slightly above the required amount, the welder hammers this until the test bushing slips over easily. This same process is carried out until the part is completely welded and hammered to size.

Holding the Metal in A Heavy Weld

Q.—Some welders have trouble holding bronze in the V when brazing on heavy work such as cylinders or locomotive frames. What can they do to improve their technique in an application of this kind?

A.—The ability to hold large puddles of molten bronze in the V when brazing on heavy work comes with years of experience. This seems to be the only way of developing this aptitude.

A substitute method can be used. A number of strips of tank steel are cut 5/16 in. thick by ¾ in. wide and of a length suitable to reach to a point at least an inch on each side of the V. The pieces are bent to conform with the outside of the desired reinforcement. After the bronze weld is started, an assistant holds one of the strips across the V, the welder then fills the dam full and applies another strip, this one is filled and this carried on until the weld is complete. This method controls the bronze and keeps a quantity of expensive bronze off the floor.

Renewing Worn Lugs on Driving-Box Cellars

Q.—What method of repair do you suggest for worn and broken out grease cellar lugs on locomotive driving boxes?

A.—There are several ways of repairing worn out lugs on driving boxes. A simple and effective method is by cutting the worn lug through with the cutting torch—if the lug is worn through this is not needed. Place two narrow strips of asbestos paper in the bottom of the cellar pin hold and insert a new cellar pin. Heat one side of the remaining lug with the welding torch and hammer it over the cellar pin. The other side of the same lug is treated in a like manner. All that is needed is to build the lug back to the original thickness with a good grade of steel rod. When the welding is completed hammer the lug into shape and strike the cellar pin a couple of good sharp blows, the asbestos paper will crumble and free the cellar pin so that it can be removed easily. This method leaves the right amount of clearance for the cellar pin.

Jim Evans, the roundhouse foreman, put a gang of laborers at work gathering and loading scrap

GOLD Is Where You Find It

by
Walt Wyre

It started before Japan snagged her sheepskin and let the wolf hair show. The United States was sending airplanes to China and scrap iron to Japan to shoot them down. Junk dealers became so busy loading scrap they didn't have time to go get their relief checks. All of them bought new automobiles and some of them found it more profitable to bale their old jalopies along with other compressed cars than to trade them in. Maybe at that they are less dangerous when molded into shells than running around on the highways.

Railroads took advantage of the booming market and started loading scrap fast as it could be gathered and gondolas spotted. Everything that looked like scrap and some that didn't was loaded and shipped. In some places, hot wells were dredged for "killed" pins, bushings, and other metal that might be found in them.

The S. P. & W. was no exception. At Plainville, as at other points on the railroad, Jim Evans the roundhouse foreman, put a gang of laborers at work gathering and loading scrap and kept them at it until even the division storekeeper couldn't have found enough scrap metal to make a sinker for a fishing line.

In the meantime, England was yelling for more guns, more airplanes, more ships, and more of everything else that might be used to convince Hitler that writing a book is one thing and making boasts come true another. The U. S. decided we might need a couple of guns and planes, too. The result was that storekeepers for once had an airtight alibi for material shortage.

One day Jim Evans was in the roundhouse office trying to decide whether to use the 5094, that had a badly cracked cylinder casting, or the 5087, that was long overdue for the drop-pit, to pull an eighteen-car soldier train, when machinist Jenkins came into the office. Jenkins does the machinist welding in the shop at Plainville.

"Say, Mr. Evans," the machinist said. "We haven't got enough bronze to build up all of the driving boxes for the 5093."

"Did you try the storeroom?" Evans asked.

"Yes, sir," Jenkins replied. "I got all they had. There's still only about half enough. Do you want me to start on them?"

"Just a minute." Evans rose and walked over to the roundhouse clerk's desk. "Tell the despatcher we'll use the 5094 on that soldier train. Now, Jenkins, let's go see what we can do about those driving boxes."

The foreman and machinist walked through the roundhouse and to the welding booth in the machine shop. "That's all of the bronze rod there is." Jenkins pointed to a pile of half-inch square bronze electrodes.

Evans shook his head and they both stood looking at the stack of electrodes. No argument about it, there was only about half enough to do the job.

"Well," Evans said, "we might cut some horse shoes out of boiler steel and weld them on the hub ends of the driving boxes. That would save enough bronze."

"Yeah," Jenkins commented, "if we had the boiler steel."

"Guess you are right," Evans said. "We haven't even got steel for the boiler side sheets yet. Say, that gives me an idea! Let's go to the roundhouse."

The two men walked into the roundhouse where the 5093 stood looking very much torn down without drivers. The two badly corroded side sheets were lying on the floor beside the trailer wheels.

"That should do it," the foreman said half to himself.

"You mean use them?" Jenkins asked.

"Why not? The staybolt holes make them so much the better. You can weld right through the holes on to the driving box, then build up over the steel with bronze for a bearing surface. Let's try it."

In the afternoon Evans went to the machine shop to see how Jenkins was getting along and found the scheme working nicely. Not only was he saving bronze but also doing the job in less time than usual.

From the machine shop Evans went to the storeroom to see if some hoped-for material, including four crosshead gibs, had arrived. It hadn't, and the foreman left, talking to himself. He stopped in the machine shop to look at the badly worn gibs. He knew by experience that building them up with babbitt wasn't usually satisfactory. It just wouldn't stay in.

Suddenly he turned and walked over to the welding booth. "Say, while we are experimenting, let's try something else," he said. "Come over here."

They walked over to where the gibs lay and squatted down on the floor as though getting ready to start a crap game. "Look here,"—the foreman pointed to a gib —"build up each end with acetylene bronze to make a sort of dam, then weld a piece of front end screen in the bottom of the gib and have the coppersmith fill up between bronze with babbitt. The front end screen will reinforce the babbitt. Then we'll plane it to fit."

"Looks all right," the machinist commented.

That idea worked even better than Evans had thought. The gibs thus repaired ran better, particularly on worn guides, than did new ones. Evans was well pleased with himself when he left the machine shop and went to the roundhouse office, but John Harris, the roundhouse clerk, smothered the foreman's good humor with a verbal blanket soaked with ice water.

"Despatcher just called," Harris said. "He wants an engine quick to send to pull the soldier train. The right cylinder fell off the 5094 and scattered all over the right of way."

"I've been trying to get a cylinder casting for over two months," Evans said dolefully. "Tell the despatcher we'll send the 5087."

After Evans had arranged for the 5087 to leave, he went to the storeroom to find out if there was any hope of getting a cylinder casting soon. There wasn't, and Evans left feeling like he would have to stand on tip-toe to look a snake in the eye.

Next day Evans was talking to H. H. Carter, master mechanic of the Plains Division, about the situation.

"There's no use trying to rush a new cylinder casting," Carter said. "There's an old casting off the 5091 at Sanford. It's pretty badly cracked. If you can figure out any way to patch it, we might use it on the 5094. I'll wire them to ship it to us."

AFTER Evans figured out a method of building up the hub ends of the driving boxes for the 5093, it wasn't long until they were ready to put the wheels under the engine. Steel for the side sheets arrived at about the same time. Everything was going along very nicely until they were ready to put the bolts in the crank arm and discovered that there were no bolts and no suitable material at hand for making them. The way it turned out, the stores department did Evans a good turn by not having the bolts. If they had, the foreman might not now have nearly two hundred feet of good quality round steel 1¾ inches in diameter. Evans wasn't looking for crank arm bolts when he stumbled on the steel. He was looking for something to use for making a shaft for a 5 hp. motor. The motor bearing had been run dry of oil, causing the bearing to burn and score the shaft. They had new bearings for the motor, but if the shaft was turned the bearings wouldn't fit and it was a case of making either a bearing or shaft. The foreman, hopeful as a prospector looking for gold, went to the water service shop and found the shop locked.

"The water service men are at the north well," a laborer told Evans.

Still hopeful, the foreman walked up to the wheel house and found two water service men and a helper installing a new pump in the well. He asked one of them about material for the motor shaft.

"No," the water service man replied, "I don't know where you could find anything like that if the storeroom hasn't got it. We haven't got anything in the water service shop."

Evans turned to leave and suddenly stopped like a bird dog that had unexpectedly discovered a covey of quail. "What's that?" Evans pointed to a pile of round steel shafting stacked against the wall.

"That's the shaft out of the old pump," the water service man said.

"What are you going to do with it?" Evans asked.

"Oh, scrap it, I guess," the water service man said.

"Not if I can help it." Evans knelt and measured the shaft. "One and three-quarter inches—just right for the motor shaft and it'll make dandy crank arm bolts," he added. Except for worn places where the bearings had worked, the shaft was good as new.

In addition to using some of it for the motor shaft and crank arm bolts, it was also used for making two valve gear pins that day and since has been a source of supply for some needed part almost every day. Evans had it hauled down to the machine shop and stacked against the wall by the hack-saw.

THE second-hand cylinder casting and the engine that needed it reached the roundhouse at Plainville the same day and it was difficult for Evans to decide which looked the worst. There were two long, deep cracks in the back of the cylinder casting. As for the 5094, she had not let loose of her right cylinder without a struggle, as bent main rod and valve gear testified. A guide yoke end was broken.

Even after the cylinder casting was unloaded, Evans walked around it two or three times trying to decide whether to try to repair and use it or not. If there had been any immediate hopes of getting a new one there

would have been no question. Reluctantly he decided to have a try at it.

The first thing he did was to have a mechanic chip out the cracks. "And be sure and chip them out deep enough to cut out all of the crack," he told the mechanic.

The next thing was a furnace for preheating the casting and keeping it hot while welding it. The furnace was built of fire-brick and covered over with some scrap boiler steel with asbestos on top of the metal. Two steel doors were made for the welder to work through. Natural gas was used to heat the casting, one burner at the bottom on each side of the furnace.

Before beginning to weld, the casting was almost hot enough to melt the bronze that was used for the job. The welder knew his stuff with an acetylene torch and did a good job of tinning the bronze to the casting and filling the V without blow holes or honeycomb spots. He built it up well above the adjoining surface so that the bronze could be chipped off and ground flush and smooth. When the welding was finished, the furnace doors were closed and the casting allowed to cool gradually.

Welding the casting was only part of the job; putting it on was something else again. Evans, by this time accustomed to encountering shortage of material, wasn't surprised when he found that there were no bolts at hand for applying the cylinder casting. This time he found the solution at the car department. An old style baggage car that had been in a wreck was being scrapped. The truss rods supplied material for making the round head 1½-inch splice bolts and 1¼-inch saddle bolts and left some material for a future emergency.

Fitting and bolting the cylinder casting was a considerable job, but the engine lacked a lot of being ready to run when that was done. The blacksmith did a nice job of straightening the main rod and valve gear. The broken guide yoke was welded and reenforced with a piece of steel which make it stronger than ever.

Evans had done so much contriving and using what had heretofore been called scrap material that every bit of metal became a potential source of material until proven otherwise. Steel from scrapped fire pans was used as liners on the shoe and wedge face of driving boxes, and it's been months since a new piece of steel has been used for tank patches. Floating liners are saved and welded on top of shoes. Knuckle pin keys are made from old valve stems. Bronze hub liners from trailers, and engine trucks that are worn thin are made to give additional service by welding sheet steel on the backs of the liners. Knuckle pins are made from old piston rods and even old arch bars are brought up from the car department to replace new material of a like size.

Steel that might be crystallized from fatigue is given a new lease on life by normalizing and heat treating which is done in a gas fired furnace. Bolts and nuts that would have once been thrown away are turned in to the tool room man who runs a tap through the nuts and a die over the bolts of all that are suitable to use again. By doing this in his spare time there is practically no labor cost.

The master mechanic has passed some of the ideas along to foremen at other points on the Plains Division and they are making use of them to conserve material and to relieve the burden on machine tools needed for the defense program.

All of this didn't come easy, and Jim Evans increased the current consumption of aspirin. Practice brings proficiency, it is said, and Evans has certainly had lots of practice figuring out how, figuratively speaking, to make bricks without straw and in some cases with very little mud.

Then, too, sometimes the necessity for using material may be avoided by proper methods, like when the left trailer wheel on the 5085 was noticed to be cutting. The 5085 is a roller bearing engine, including the trailers, and it was apparently lined perfectly, but the left wheel continued to cut while the right wheel did not. It was not cut badly, but in just one or two more trips the wheels would have been removed and turned. Evans caught the condition before it was cut enough to take the gauge. He ran the engine over the drop-pit, dropped the trailer wheels and turned them around, figuring that the right wheel which was on the left side after the wheels had been turned around would perhaps start cutting, but the one on the other side would stop cutting. That is exactly what happened, except after the wheels were turned around the cutting stopped almost entirely and the trailers will apparently run just as far as they would if they had been turned in the wheel lathe.

Evans has been pretty lucky and maybe there's not so much luck to it either, keeping things going, but every once in a while, almost every day in fact, he runs up against a proposition that seems impossible to handle, and some of them are. That almost happened with the 5080.

Evans was figuring on using the engine next day and everything was going along about as well as could be expected. The foreman walked through the roundhouse and out to the machine shop and noticed the cross-head gibs all set up to be babbitted, but apparently no one was working on them. Evans went to find the coppersmith that was supposed to be doing the job. He found the coppersmith doing some pipe work on another engine.

"How you coming on the cross-head gibs for the 5080?" Evans asked.

"Haven't got any babbitt," the coppersmith replied.

"None in the storeroom," Evans remarked rather than asked.

"Not an ounce, and I've dug up every bit I can find anywhere. The last job I did I had to scrape the pot, then was a little short."

"Let's go see what we can find," Evans said.

It seemed that search as they would, there was no babbitt anywhere. At the water service shop where Evans had hoped to find some of the metal the water service man said he was badly in need of babbitt himself and was figuring on going to the roundhouse in search of some.

"Maybe we might find enough car brasses at the car department that we could melt the babbitt off," the coppersmith suggested.

"That might be an idea," Evans agreed. "You go on back and finish the job you were working on. I'll go down to the car department."

"No, since the defense program started we send our old brasses in almost as fast as we take them off and we haven't got any babbitt. We don't run any bearings here, you know."

Evans stopped at the storeroom on the way back and asked when and if some babbitt was expected. The reply was "next week, maybe."

The foreman went to the machine shop just about ready to give up. He walked around in the machine shop, then out the west door where there is a platform built of old channel iron laid on the ground. They have a portable gas burner there that is used for heating, melting babbitt off, boxes, etc. For some time the S. P. & W. babbitted the hub end of driving boxes by fitting a piece of flat iron around the end of the box and fitting it with babbitt, then removing the piece of iron. Each time a box was rebabbitted the old metal was melted off.

(*Concluded on page 536*)

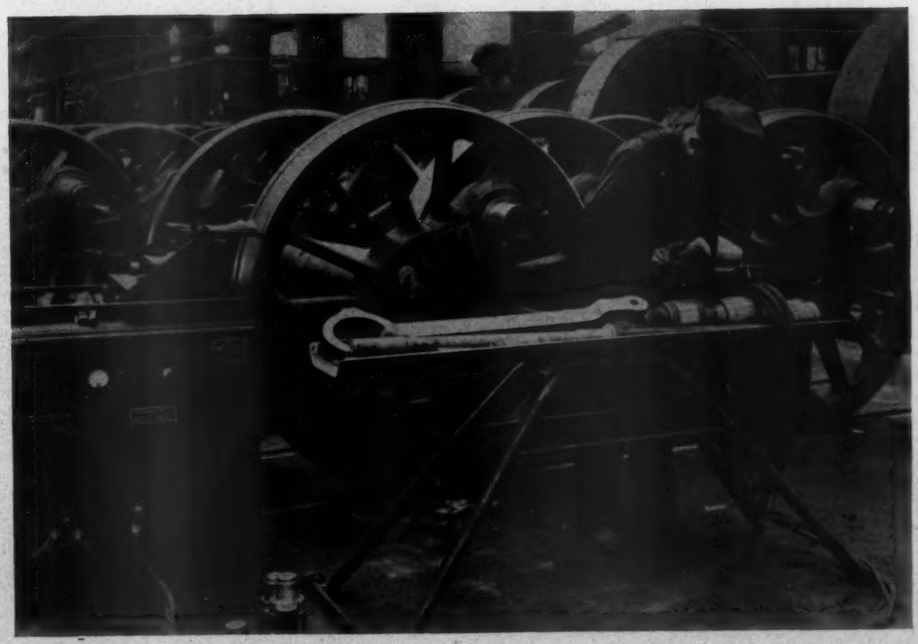
Convenient Equipment For Magnaflux Testing

Two devices for the convenient Magnafluxing of locomotive parts are shown in the illustrations, one consisting of a set of rolls used in testing driving axles and the other a convenient portable steel tray or stand for use in testing small parts, such as valve rods, piston rods, wrist pins, knuckle pins. etc. In view of the necessity for more careful and thorough checking of an increasing number of locomotive parts by this method, any devices such as those illustrated and now in use at the Atchison, Topeka & Santa Fe shops, Albuquerque, N. M., demontrate their value in a very practical way.

Referring to the view in which a driving axle is being Magnafluxed it will be noticed that the mounted wheels and axle are resting on a set of old valve-setting rolls which are air-operated through reduction gears and two drive shafts to the small rolls which support the driving wheels. Usually about three coils of wire are looped around the axle and a heavy electric current from the Magnaflux machine creates a magnetic field in the axle which causes the powder to show up clearly any surface defects or potential fractures. Inasmuch as the axle has to be examined minutely throughout its entire length and circumference, the valve-setting rolls enable this work to be done with the operator standing in one position and without the necessity of rolling the wheels and moving the Magnaflux wire along the shop floor.

For Magnafluxing the short rods and locomotive parts mentioned, the pipe-supported tray or stand is exceptionally convenient and a great time saver. This stand consists of a piece of ¼-in. tank steel, 68 in. long by 11 in. wide, flanged on either side enough to keep the small locomotive parts from rolling off and welded to a sup-

Old valve-setting rolls provide a convenient means of revolving locomotive driving wheels while Magnafluxing the axles



Portable steel tray or stand which affords a quick and convenient way of testing small locomotive parts by the Magnaflux method

porting framework of 1-in. steel pipe, bent and braced to the shape shown. The height of the stand is 32 in. and two legs of the pipe are equipped with small rollers so that by lifting the other two legs, the device may be readily moved about the shop. Not only does this device save labor and time in handing the small locomotive parts while being tested, but it also saves Magnaflux powder which drops to the tray and can be collected for re-use after each group of locomotive parts is tested.

Locomotive Boiler Questions and Answers

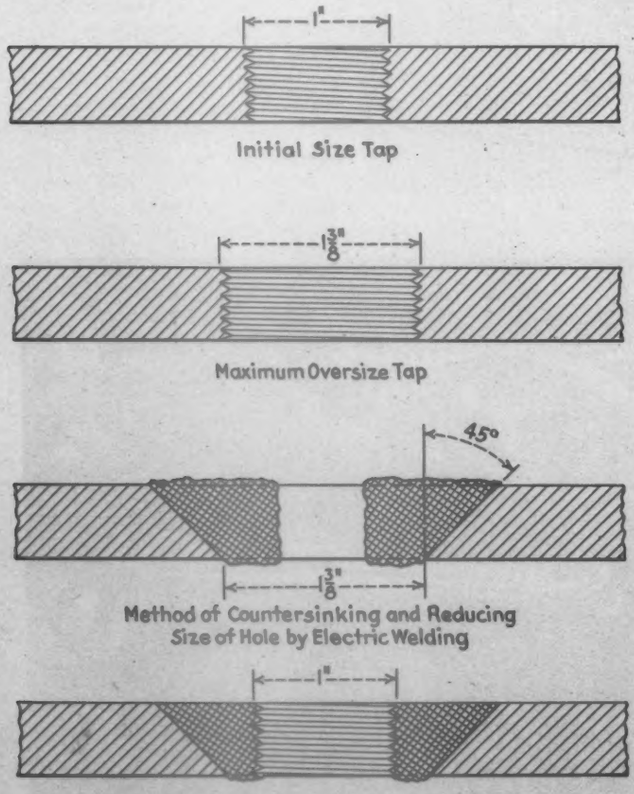
By George M. Davies

(This department is for the help of those who desire assistance on locomotive boiler problems. Inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless special permission is given to do so. Our readers in the boiler shop are invited to submit their problems for solution.)

Repairing Tapped Holes In Boiler Sheets

Q.—Is it satisfactory to repair the tapped holes in a wrapper sheet for the rigid taper-head staybolts of a locomotive boiler by plugging them with electric weld and drilling and retapping new holes?—M. Z.

A.—When the rigid taper-head staybolt threads in the wrapper sheet are worn and need renewing, the sheets should be retapped for oversize staybolts. When the maximum oversize thread has been used, the holes may then be welded and retapped to their original size, in the manner illustrated, provided no cracks, radiating from the staybolt holes, are found in the wrapper sheet.



The manner in which tapped holes in boiler sheets may be renewed by welding

Heat Losses Due to Scale

Q.—When a locomotive boiler tube becomes coated with scale, what heat losses are incurred due to the scale?—F. I. D.

A.—Professor Schmidt of the University of Illinois has given the following table for heat losses in boiler tubes due to various thickness of scale. There have been various other values given but these figures are considered authoritative by a good many engineers.

Thickness of scale, in.	Per Cent Loss of Heat: Soft Carbonates	Hard Carbonates	Hard Sulphates
1/50	3.5	5.25	3.0
1/32	7.0	8.3	6.0
1/25	8.0	9.9	9.0
1/20	10.0	11.25	11.0
1/16	12.5	12.6	12.6
1/11	15.0	14.3	14.3
1/9	...	16.0	16.0

Carbon Steel Rivets In Nickel Steel Sheets

Q.—Would the efficiency of the longitudinal seam of a nickel-steel boiler be affected by replacing the nickel-steel rivets with carbon-steel rivets?—F. P. S.

A.—The effect of replacing nickel-steel rivets with carbon-steel rivets in the longitudinal seam of a nickel-steel boiler would be to reduce the rivet shear from 60,000 lb. to 44,000 lb. in single shear and from 120,000 lb. to 88,000 lb. in double shear. To determine the actual effect on the efficiency of a given seam, the seam should be calculated using both values for single and double shear of the rivets. By calculating a typical example of a quadruple riveted butt and double strap seam, it shows that the efficiency of the seam is reduced from 91.4 per cent to 85.9 per cent when carbon-steel rivets are used in place of nickel-steel rivets.

Gold Is Where You Find It

(Continued from page 534)

Evans looked around over the platform, but every scrap of the metal had been removed. The only piece he saw was a little sticking up in a crack between two of the channel irons. Every little bit would help. He stooped and took hold of the finger of babbitt. It wouldn't budge. He pulled harder. He went to the blacksmith shop and returned with a small pair of tongs. He reached down with the tongs, grasped the piece of babbitt, and pulled. It still wouldn't budge.

The portable gas electric crane was working nearby stacking some driver tires. Evans caught the crane operator's eye and motioned for him to come.

"Pick up one end of that channel iron with the crane hook," Evans told the crane operator.

Then the foreman saw why he could not pick up the piece of babbitt. It was part of a chunk that had run through the crack and down under the channel iron. Evans got a couple of laborers to help and with the crane lifted up all of the channel iron floor. There wasn't a gold mine, but there was over a ton of babbitt that had over a period of years melted and run through the cracks in the channel iron floor.

Birch Single-Car Testing Device

The present type of single-car testing device is of rotary-valve construction and hence subject to scoring of the valve or its seat. This at times undesirably connects one on to another and gives a false indication, and the defect in the testing device is not discovered until it is itself tested in a specially-designed test rack. Since test racks are usually located only at main points where facilities are available for making repairs, the testing devices must be shipped to such points and returned again, exposing them to damage in handling. Duplicate devices are also required to replace those en route to and from such repair points.

To overcome the difficulties mentioned, T. H. Birch, air brake foreman, Chicago, Milwaukee, St. Paul & Pacific, Milwaukee, Wis., has designed a single-car testing device which has been thoroughly tested and recently authorized for use by the Association of American Railroads. Patent application has been filed. The functions of this new type tester are identical with the present A. A. R. standard device but, instead of having a rotary valve, the rate of reduction or increase in brake-pipe pressure is governed by separate and individual valves. Nos. 1, 2, 4, 5, 6, and 7, respectively. For instance, with No. 1 valve open and the other valves closed, this position is identical with Position 1 of the Westinghouse device. With No. 2 valve open and all other valves closed this setup is identical with Position 2 of the Westinghouse device; and with all valves closed it is identical with Position 3. By opening No. 4 valve with all other valves closed, it is the same as Position 4; opening No. 5 valve with all other valves closed is the same as Position 5; and with No. 6 valve open and all others closed it is identical with Position 6. In opening No. 7 valve with all others closed, it is the same as opening the ⅜-in. test-device cock. Positions 1, 2, 3, 4, 5, and 6, with the ⅜-in. test-device cock refers to the positions obtained in the present A. A. R. single-car testing device, shown on pages 24 to 27 of the Westinghouse Instruction Pamphlet No. 5039-4.

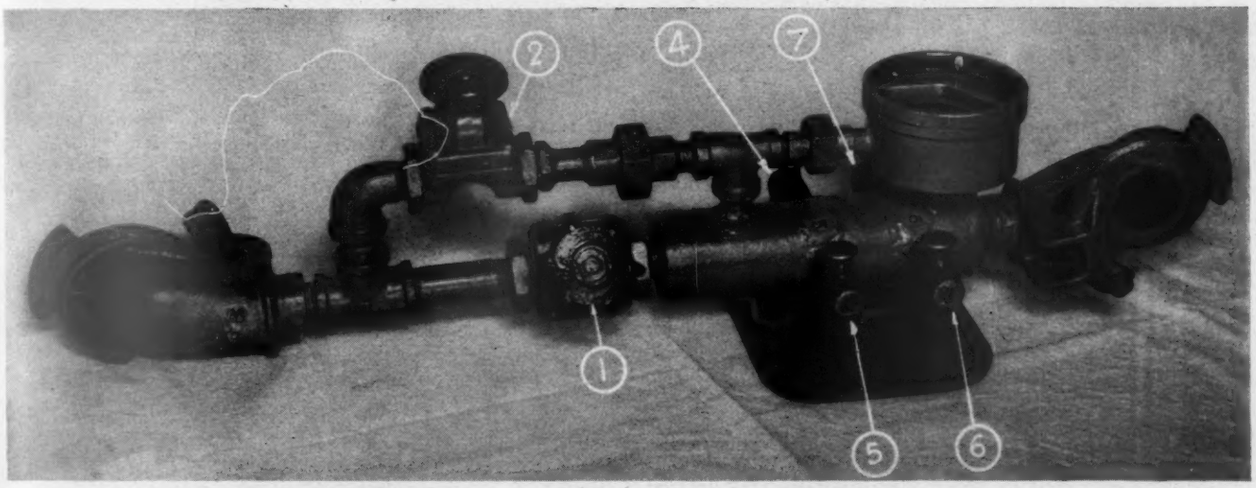
In the new device, the rates of brake-pipe reduction are controlled by a choke fitting with the proper-size orifice inserted in the nipples, to which the self-closing valves are attached. The rate of increase in brake pipe pressure is controlled by an orifice set in the union (2).

The advantages of the new-type single-car testing device are said to include the following:

(1) Leakage can be immediately detected at the local point and remedied at that local point without shipping to any main point for test-rack test. The device is charged, and after disconnecting it from the air supply, the gage is noted for any drop in air pressure, which indicates leakage.

(2) If leakage exists, the device can be immersed in water while it is still charged with air pressure and the point of leakage will be located by rising bubbles.

(3) Inasmuch as this leakage would usually be found in the rubber seats which are part of valves 4, 5, 6, and 7, on the diaphragm which is a part of valves 1 and 2, correction can be made immediately by renewal of either the rubber seat or the diaphragm. The construction of these valves is such that, in order to renew the rubber seat in valves 4, 5, 6, and 7, it is only necessary to remove the cap nut, change the rubber seat, and then replace the nut. In order to change the diaphragm in valves 1 and 2, remove the four machine screws, then remove the bonnet and thereby expose the diaphragm.



1—Full release
2—No. 74 drill orifice
4—No. 65 drill orifice
5—5/64-in. drill orifice
6—No. 26 drill orifice
7—¼-in. drill orifice

Birch single-car testing device now officially authorized for use in testing air brake equipment

* * *

No. 6 Gerlinger gasoline-operated lumber-handling truck and skids at the Missouri Pacific shops, Sedalia, Mo.

Air Brake Questions and Answers

AB-8, Empty and Load Equipment (Continued)

35—*Q.—How many positions has the transfer piston?* A.—Two. Closed, in which it remains on the upper seal. Open, in which it seats on the lower seal (cover gasket).

36—*Q.—What does the piston do in the upper, or closed, position?* A.—It cuts off the load cylinder in empty position.

37—*Q.—What does it do in lower, or open, position?* A.—It connects the brake-cylinder pipe to the load cylinder in load position.

38—*Q.—Does the transfer valve open immediately?* A.—Not until 20 lb. empty cylinder pressure is built up.

39—*Q.—What brings about this delayed opening?* A.—Spring *46* is of such a value that 20 lb. empty cylinder pressure is required to overcome it.

40—*Q.—There is a plunger (3) positioned on the transfer piston. What is its function?* A.—It functions to control the position of empty cylinder check valve *47* through transfer piston movement.

41—*Q.—What is the duty of the empty cylinder check valve?* A.—With its spring it prevents back flow from the empty to the load cylinder.

42—*Q.—What is the duty of the release check valve?* A.—With its spring it prevents the release from the empty cylinder until a predetermined initial release takes place from the load cylinder and controls the desired difference in pressure in the empty and load cylinders during release.

The Strut Cylinder

43—*Q.—What is the purpose of the strut cylinder?* A.—Its purpose is to measure the car truck spring deflection and automatically condition the brake for empty operation when the car is less than half loaded, and for load operation when the car is over half loaded.

44—*Q.—Where is it installed?* A.—On the end of the truck bolster (Fig. 8).

45—*Q.—Referring to Fig. 9, what parts are contained in the body portion and where is it fastened?* A.—It is bolted to a bracket having two pipe connections and contains a piston equipped with a ring and piston rod. The rod is connected through the piston spring to a foot outside the body.

46—*Q.—What is the normal position of the piston?* A.—In release position it is up.

47—*Q.—During the recharge period, what movement occurs?* A.—Air from the cut-off portion causes the piston to move down until the foot comes in contact with a piston stop on the truck.

48—*Q.—What determines the amount of travel of the piston in its cylinders?* A.—This depends on the truck-spring deflection, inasmuch as the strut cylinder is mounted on the truck bolster, and the piston stop on the truck member below the truck spring.

49—*Q.—What is the relation of piston stroke to car load?* A.—The piston stroke decreases as the car load increases, due to the fact that the piston is brought closer to the piston foot on account of the deflection of the truck spring.

50—*Q.—With a car less than half loaded the setting should be determined as empty. How is this accomplished?* A.—A port from the change-over portion and leading into the cylinder wall is exposed by the piston stroke under the above condition which admits air from the change-over valve.

51—*Q.—With a car more than half loaded, the setting should be determined as load. How is this accomplished?* A.—The port is not uncovered due to the fact that the piston stroke is insufficient. The face of the change-over valve piston is now open to the atmosphere through the strut cylinder exhaust.

52—*Q.—At what brake-pipe pressure is the strut operated to determine the setting?* A.—Only at such time as the brake-pipe pressure is under 30 lb.

53—*Q.—In view of this feature, how is the longevity of the strut cylinder parts affected?* A.—There is no wear from truck vibration as the piston and foot valve is always retracted.

54—*Q.—What indicates that the change-over valve is in empty position?* When the empty brake cylinder piston moves out alone.

55—*Q.—If the brake pipe has been depleted, recharged and an application made, what piston movement results?* A.—Both cylinder push rods should move out; an indication that the equipment is in load position.

56—*Q.—During the preliminary charging of the change-over valve, how does the brake-pipe air get to the slide valve chamber K of the cut-off valve portion?* [Note: These references are to Plate 1—Operation—EDITOR.] A.—Through the strainer and choke in the ABEL-1 pipe bracket and pipe *11* to the change-over valve bracket and choke *103* to the slide valve chamber.

57—*Q.—What holds it in this position?* A.—Spring *76* above cut-off diaphragm *72*.

58—*Q.—What communications are open in this position?* A.—Through passage *9* to the strut cylinder volume and to chamber *D* on the face of latch piston *20*, and to the upper side of strut cylinder piston *3* via pipe *9*.

59—*Q.—At what point does the piston shoe contact the piston stop?* A.—When sufficient air pressure is obtained to force the strut cylinder piston down, which is approximately 13 lb.

60—*Q.—As it is necessary to obtain air in chamber A on the face of the large change-over piston on an empty car, how is this accomplished?* A.—Due to the strut cylinder piston movement, the lower port in the side of the cylinder is uncovered. This permits a flow of air from the strut cylinder through pipe *4* in the change-over valve to the chamber on the face of the large change-over piston.

61—*Q.—What moves the latch 27 away from contact with the change-over piston?* A.—This is brought about as the latch piston moves in and by means of angle lever *26*.

62—*Q.—When does this happen?* A.—When air in chamber *D* on the face of the latch piston builds up to about 20 lb.

63—*Q.—With the same air pressure now acting on the face of the two change-over pistons, what happens?* A.—The piston moves to its empty position on account of the difference in the piston area.

64—*Q.—During the release and full charge (empty position-Plate 2) what causes the cut-off piston and slide valve to move to cut-off position?* A.—When the air pressure beneath the cut-off-valve diaphragm is more than 20 lb., the diaphragm is deflected by its spring resulting in movement of cut-off piston *66* and slide valve *67* to cut-off position. Passage *9* is then connected to the exhaust port *At* in the change-over piston via the

slide valve cavity. Air is thus vented from the strut cylinder, the face of the small change-over piston and the face of the latch piston.

Pneumatic Conveyor System Speeds Riveting Jobs*

The accompanying photographs show a type of pneumatic rivet conveyor system developed by Clarence Reynolds, general foreman, boiler department, South Louisville shops of the Louisville & Nashville. Through the use of this device hot rivets propelled by compressed air can be shot through heat-resisting hose at a speed of 75 ft. a second for distances as great as 400 ft. horizontally and 75 ft. vertically. Any size rivet can be conveyed, provided the hose and conveyor gun are of the proper size; the equipment shown is for 5/8-in. rivets.

After being heated, the rivet is placed head-first in a slotted metal tube coupled to the hose and positioned in a device that is connected to the compressed-air supply. The pressure of the operator's foot on a pedal slides a jacket over the rivet, effectively chambering it and simultaneously releases compressed air into the chamber. Generally a pressure of about 85 lb. per sq. in. is used. Under the impetus of the compressed air, the rivet passes through the hose and drops into a stopping cup where it can be removed and applied.

An advantage of this type of conveyor system is that rivets can be conveyed around corners and to places where it would be difficult to toss them without a relay. One rivet heater can supply as many as three widely separated riveting jobs at the same time.

* Reproduced, in part, from the L. & N. Magazine.

General view of the conveyor system showing the manner in which a hot rivet is dropped into the receptacle

The foot pedal arrangement, showing how the chamber is closed after the rivet is inserted

Decisions of Arbitration Cases

(The Arbitration Committee of the A. A. R. Mechanical Division is called upon to render decisions on a large number of questions and controversies which are submitted from time to time. As these matters are of interest not only to railroad officers but also to car inspectors and others, the Railway Mechanical Engineer will print abstracts of decisions as rendered.)

Intermediate Line Card Final As to Axle Dimension

The Western Maryland changed wheels on American Refrigerator Transit car No. 481 on account of an owner's defect, the wheel statement reporting second-hand axles of proper dimensions having been put in and removed. Subsequently, the Baltimore & Ohio removed the wheels and the axle previously applied by the W. M. on account of defects in both wheels and scrapped the axle because of a small wheel seat, the B. & O. applying new wheels and a second-hand axle in replacement thereof. The car owner forwarded both sets of repair cards to the W. M. in joint evidence under Rule 90 requesting adjustments to cover charges connected with wrong repairs. The W. M. refused to recognize the B. & O. repair cards as holding the final authority of joint evidence and refused adjustment. The A. R. T. contended that the scrapped axle was necessarily removed by the B. & O. and replaced by a good axle in order to comply with the requirements of Section (a), Rule 86 and to avoid responsibility in perpetuating wrong repairs. The A. R. T. requested adjustment equivalent to that which would be billed against the W. M. if their defect card had been issued in accordance with Rule 87 including the difference in material value between second-hand and scrap axle; also labor and incidentals associated with repairing owner's defects and the correction of wrong repairs according to the principal established in the third condition described in Interpretation (12) to Rule 107. In its statement of facts, the W. M. contended that in view of the original record of repair which established the fact that the axle applied was of the proper size, the B. & O. repair card could not be considered as joint evidence under Rule 90. The repairs were not made by the B. & O. until eight months after repairs were made by the W. M. and, for that reason, the W. M. would not consider the B. & O. as an intermediate

line under provisions of Rule 90. The W. M. requested clarification in connection with the proper application of Rule 90 in the use of a subsequent repair card as joint evidence: (1) Does the rule establish an indefinite time limit? (2) Extent of responsibility of road originally making repairs in connection with the case under discussion; (3) Can a road be considered an intermediate line regardless of the number of times the car is interchanged prior to repairs or is it the intent of the rule that the correction of improper repairs should be made on the first interchange movement subsequent to the date the original repairs were made?

In a decision rendered January 31, 1941, the Arbitration Committee stated that investigation of B. & O. wheel shop records developed that the wheel seat measurement was taken before turning and without any allowance for metal that would be removed due to turning. The car not having been home between the date the axle was applied by the W. M. and the date it was removed by the B. & O. Rule 90 governs and the contention of the A. R. T. is sustained.—*Case No. 1782 American Refrigerator Transit versus Western Maryland.*

Substitution of Truck Bolster Constitutes Temporary Repairs

On September 23, 1939, the Illinois Central applied a second-hand cast-steel truck bolster to car SDRX No. 1884 to replace a broken pressed-steel bolster and rendered a bill against the Sinclair Refining Company in accordance with Rule 101, item 114 and Rule 104, Section L of the 1939 code. An I. C. defect card was not attached to the car for the correction of wrong repairs. The owners executed a joint evidence card and forwarded it to the I. C. which company furnished defect card for labor only to the Sinclair Refining Company. That company took exception to the fact that the charge was confined to labor only, contending that certain undesirable features of the cast-steel bolster rendered it unsuitable as a permanent repair. The Sinclair Refining Company contended that Decision No. 1745 covered a similar case in that a bolster unsuitable for permanent use under a car can be considered only as temporary repairs. The I. C., in its statement, justified the issuance of a defect card for labor only on the ground that it complied with their interpretation of Rule 88 and contended further that certain differences in dimensions between the standard and the cast-steel bolster could have no effect on the service of the bolster as there are numerous cars in service, the bolsters of which differ in dimension in a similar manner.

In a decision rendered November 14, 1940, the Arbitration Committee stated: "The joint evidence indicates that the bolster applied was unsuitable for permanent use under the car in question and can only be considered as temporary repairs. The principal of decision No. 1745 applies. The contention of the Sinclair Refining Company is sustained."—*Case No. 1781, Sinclair Refining Company versus Illinois Central.*

Low-Center Flat Cars Built At Sacramento Shops

From the point of view of the car foreman and the car inspector, one of the most interesting jobs recently done at the Southern Pacific shops, Sacramento, Cal., was the

(*Continued on next left-hand page*)

Stack-drilling six web plates at a time with each of two radial drills at Sacramento general shops

175,000 MILES IN REFRIGERATOR CAR SERVICE

Hare Photographs, Inc.

4 SAVINGS WITH CHILLED CAR WHEELS:

1. Lowest cost per mile.
2. Increased rail life.
3. Increased brake shoe life.
4. Reduced machine shop costs.

During the 10 years since these chilled car wheels were installed, improvements in design, manufacture and inspection have set increasingly higher standards for all of the wheels we make.

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230 PARK AVENUE,
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building of 10 reinforced steel depressed-center flat cars required to haul oversize loads, such as the 57-ton marine boiler, illustrated. This car is 52 ft. long, weighs 66,000 lb., and has a nominal carrying capacity of 70 tons. The depressed center of the car varies from 2 ft. 2 in. to 2 ft. 6 in., above the rails, dependent upon the load. Owing to the heavy construction required to carry large concentrated loads at the center of this car, also the relatively small number of units built, the cost per car is approximately $5,000.

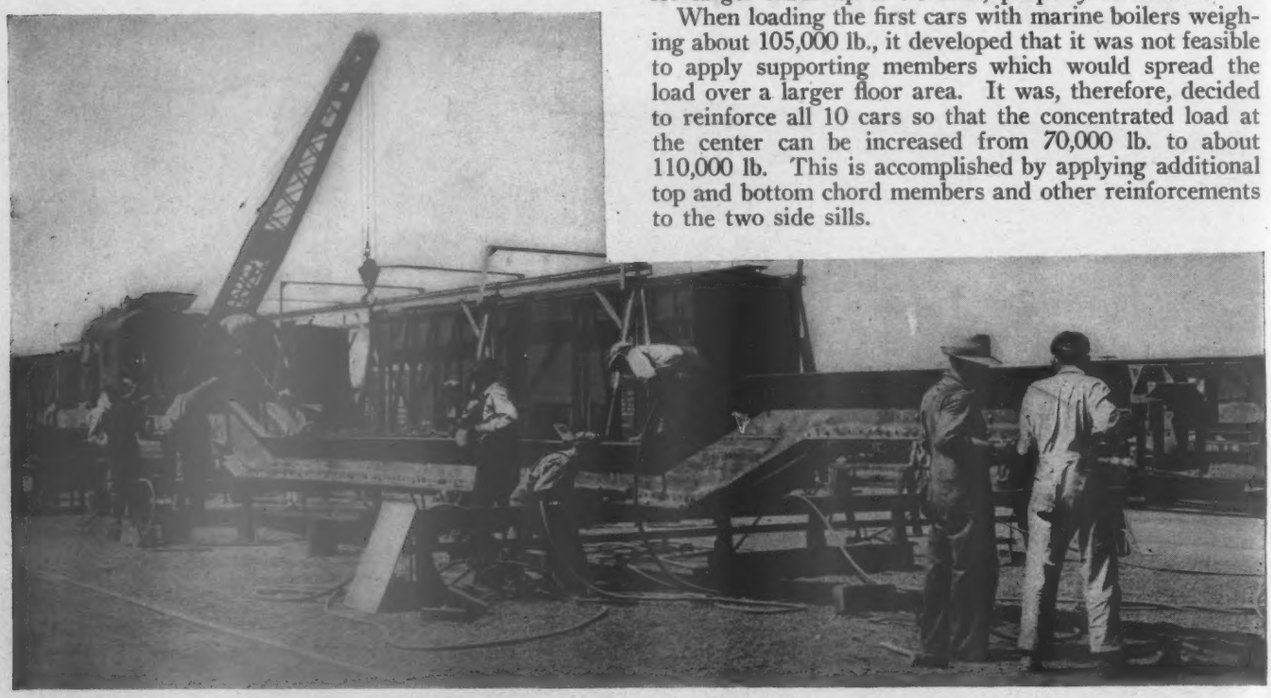
According to an article published in the Southern Pacific Bulletin for November, the main items of the car body are the four longitudinal members (two center sills and two side sills) each of which had to be built up of plates and angles. As no steel plates of about 36 in. width and 52 in. length were available, each web plate of these sills was made of the following five pieces of plates, cut to the proper shape and then welded together: Two end pieces, about 16 in. wide and sloped at one end, one center piece, about 16 in. wide and sloped at both ends in the opposite direction, and two small intermediate plates, from 3½ in. to 5 in. wide, with the ends sloped parallel to each other. The resulting plate is 35½ in. wide overall, with portions about 19½ in. wide cut out at the ends and center.

A row of holes is then drilled along the top and bottom edges of the web plates for application of the top and bottom chord angles. About six plates are placed together and drilled at the same time. The holes in most of the remaining longitudinal members are punched instead of drilled, after a jig has been made which insures the proper spacing. When riveting the chord angles to the top and bottom of the web plates, these angles are straight and are first riveted to the depressed or center portions of the web. They are then heated and bent parallel to the edges of the sloped portions of the web and riveted thereto. The ends are then bent again and riveted to the horizontal ends of the web plates. The two center sills are provided with the necessary spacers, and a ¾-in. by 28-in. plate is riveted to the bottom to form a single column. A narrower reinforcing plate is applied to the bottom of the side sills.

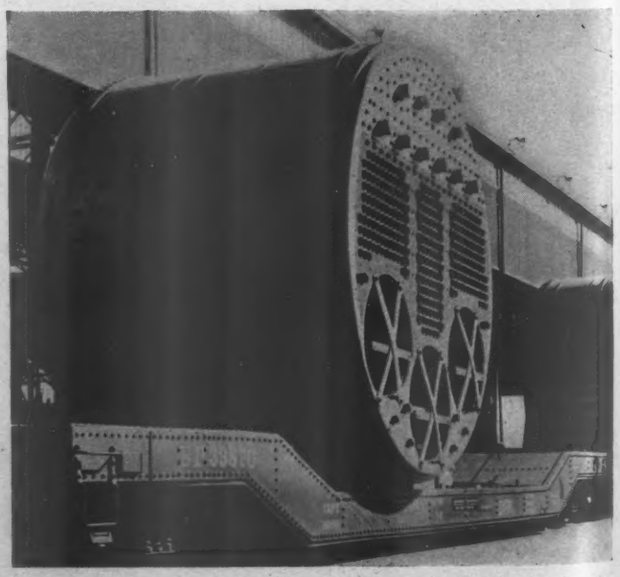
The next step is to apply the transverse members (end sills, bolsters, crossbearers and crossties) to the center sills and to rivet the side sills to the ends of the transverse members. The last step in constructing the body is to rivet the floor plates to the various framing members and to weld the joints between the plates to obtain a continuous surface from end to end of the car. These plates have holes for the bolts securing the loads and other holes large enough for a man's hand to permit the insertion of these bolts.

It is the usual practice to design such cars for a concentrated load of 70,000 lb., or half the nominal capacity, loaded within a space of 3 ft. at the center of the car, or for larger loads up to 70 tons, properly distributed.

When loading the first cars with marine boilers weighing about 105,000 lb., it developed that it was not feasible to apply supporting members which would spread the load over a larger floor area. It was, therefore, decided to reinforce all 10 cars so that the concentrated load at the center can be increased from 70,000 lb. to about 110,000 lb. This is accomplished by applying additional top and bottom chord members and other reinforcements to the two side sills.



Riveting chord angles to web plates in the process of building the heavy main sills of the car



Southern Pacific low-center flat car carrying 57-ton marine boiler built in conjunction with the national defense program

(*Turn to next left-hand page*)

TWELVE MORE 2-8-4's

FOR

One of twelve new high-speed, 2-8-4 type freight locomotives recently delivered to the Pere Marquette Railway Company by The Lima Locomotive Works, Incorporated. The excellent performance of the fifteen 2-8-4 type locomotives that were delivered to the Pere Marquette by Lima during the latter part of 1937 convinced the railroad that locomotives of this type would be the most economical and efficient means of augmenting their existing power to meet today's traffic demands.

Pere Marquette Railway Company

WEIGHT IN WORKING ORDER, POUNDS				
On Drivers	Engine Truck	Trailer Truck	Total Engine	Tender 2/3 Capacity Loaded
277600	50900	Front 56000 Back 58000	442500	284800
WHEEL BASE			Tractive Power	Grate Area
Driving	Engine	Engine & Tender		
18'-3"	42'-0"	88'-2¾"	69350	90.3
BOILER		CYLINDERS		Diameter
Diameter	Pressure	Diameter	Stroke	Driving Wheels
87-15/16" OD	245 lbs.	26"	34"	69"

LIMA LOCOMOTIVE WORKS INCORPORATED, LIMA, OHIO

LIMA LOCOMOTIVE WORKS INCORPORATED

High Spots in

Railway Affairs . . .

Profit in Suggestions From the Employees

The Illinois Central has maintained an employees' suggestion plan for several years. About two and a half years ago it made some changes which have considerably speeded up its productiveness. In a period of 27 months under the new arrangement, more than 38,000 suggestions were made, about 10 per cent of which were adopted. Some of the ideas are of a minor nature and such that the benefits cannot be measured in dollars and cents. Nominal sums are paid for such ideas, even though the benefits are intangible. Where suggestions results in savings and the profits can be measured, based on labor, materials, supplies, etc., awards are made approximating 10 per cent of the net savings for the first year. The awards, which totaled $37,000 for the period mentioned, ranged from a minimum of $5, to a maximum of $1,863. One of the mechanical department employees has won 56 times since the beginning of the plan. Others, both male and female, are frequent repeaters. The employee fills out a suggestion blank when he makes his recommendations. The system is administered by a small staff, under the jurisdiction of the assistant to the president, all of the time of the staff being concentrated on this particular activity.

Engineering Convention Exhibits

Unlike the mechanical department associations, which are restricting their annual meetings to those of their general or executive committees, or are eliminating the meetings entirely, the railroad engineering associations continue to go merrily on with their conventions and also with their exhibits. The National Railway Appliances Association, which makes its exhibit in Chicago at the time of the convention of the American Railway Engineering Association, has just announced that next March it will utilize the 122nd Field Artillery Armory. This is closer and more convenient to the convention headquarters, and it will be possible to house all of the exhibitors within one large area. The promoters of the exhibit believe that there will be a considerable increase in the number of companies that will exhibit next March.

Steel Distribution Badly Administered

Washington today controls the allocations of steel. Railroads, a vital factor in national defense, are deeply concerned because of the lack of steel for building freight cars and locomotives. John H. Van Deventer, capable editor of Iron Age, and certainly an authority on steel production, pointed out to the Executives Club at Chicago a short time ago that, at an outside calculation, not more than 40 per cent of the present steel producing capacity is required for defense purposes. "On the basis of our present ingot-producing rate, 80 million tons," he said, "the remaining 60 per cent which should be available to non-defense industries amounts to 48 million tons, or enough to permit these non-defense industries to do business almost on their 1939 basis." Again he said, "So long as we have at least 60 per cent of our present steel-making capacity theoretically available for non-defense business, the chief reason for anyone not getting at least some steel is mal-distribution. We have priorities, and having priorities in the way that we have had them, we have got ourselves into a mess, because priorities are being used as a substitute for planning."

Trans-Saharan Railroad

The renewed hostilities in North Africa have done much to focus attention on the railroad now being built across the Sahara Desert by the Vichy government. The Railway Age in discussing why a railroad was decided upon, rather than highway or water transportation, refers to studies made by French experts in 1929 and 1930. A train hauling up to 3,000 net tons on a direct route, at 40 m.p.h., would require two crews of three men each to make the trip. A coastwise cargo vessel handling the same tonnage, over a round-about route and traveling at a speed of 15 m.p.h., would require a minimum crew of 15. The same load carried by highway trucks would require 600 five-ton trucks and a minimum of 1,200 drivers for the long journey. Estimated costs of transportation over the entire route would amount to from 300 to 1,000 francs per metric ton by railroad, 7,000 to 10,000 francs by trucks over a highway on the assumption that it would be paid for by the users as in the case of the railroad, and 12,000 francs by air.

The Railroads' Future

In addressing the National Industrial Traffic League annual luncheon at Chicago, President Ernest E. Norris, of the Southern Railway, spoke frankly of the problems which confront the railroads. He emphasized the fact that when "this insane world war" is over "the railroads will have to face new and desperate competition for whatever traffic there will be." In concluding his address he said that "the railroads are going to lick the problems of tomorrow; the problems of depression, of competition, of dwindling revenues and inflexible expenses, of inequalities in the treatment of different forms of transportation." They will win out, he said, "partly because they have what it takes to do the job, the inherent strength, the resourcefulness, the courage, the will, the talent. But it will be the co-operation of the nation's shippers and the support of the American people that will really make this prediction come true."

Export Traffic in October

The railroads, in conjunction with the government and with splendid cooperation on the part of the shippers, are getting a high standard of productiveness from their freight cars. No longer, as was true in the first World War, are the freight cars being used for storage purposes. In October of this year 63,413 cars of export freight, other than grain or coal, were unloaded at Atlantic, Gulf and Pacific ports; this compared with 47,559 cars unloaded during October a year ago. There was also a very large increase in the amount of grain handled for export, 3,232 cars being unloaded in October of this year, as compared with 685 in the same month last year. The A.A.R. reported that, "No congestion or delay to traffic exists at any of the Atlantic, Gulf or Pacific ports, due to the co-operation of the steamship lines, port authorities, exporters and shippers."

Passenger Traffic Progress

The railroads, because of competition from other types of carriers, have suffered a heavy decline in passenger traffic during the past two decades. The introduction of streamline trains and the modernization of passenger equipment, with the speeding up of the service, turned the tide, so that the passenger traffic during the first two-thirds of 1941 was larger than the first two-thirds of any year since 1929, and in fact, was only 10 per cent smaller than in 1929. The Railway Age, in its annual Passenger Progress Number, not only stresses these facts, but points out that it was larger in the first two-thirds of 1941 than in any of the entire years 1932 to 1935, inclusive. There is no question but what the improvements in the passenger service have had a profound effect in cultivating a better attitude toward the railroads on the part of the public. There is evidence, also, that this has been reflected in an increase in freight traffic on the part of some of the shippers. The results have been inspiring to railroad management and have undoubtedly contributed to increased activities on a number of roads in systematic research of traffic problems.

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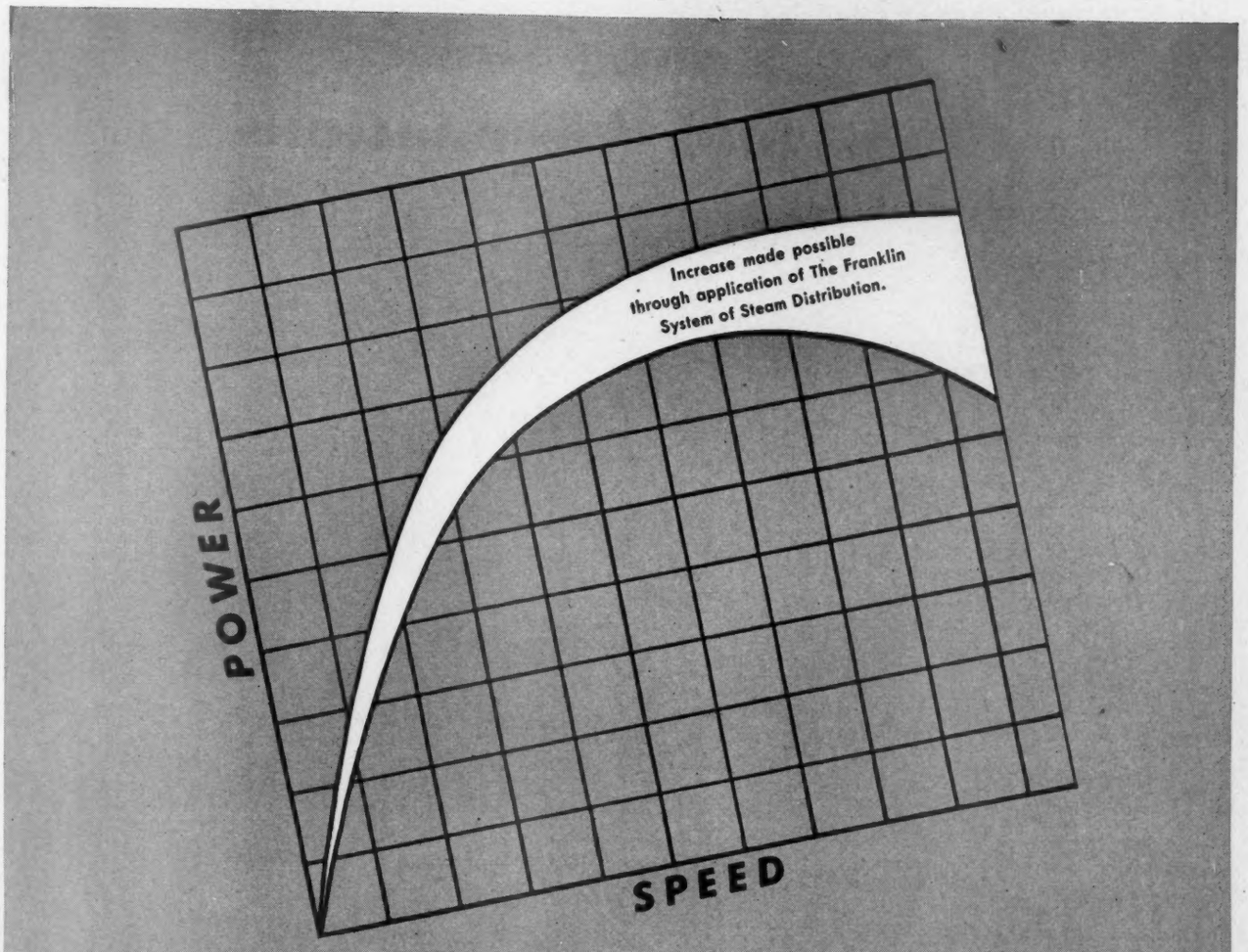

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Among the Clubs and Associations

NEW ENGLAND RAILROAD CLUB.—Meeting December 9, Hotel Touraine, Boston, Mass. Speaker: Paul C. Dunn, Boston & Maine. Subject: Selection and Training of Railroad Supervisors.

CAR DEPARTMENT ASSOCIATION OF ST. LOUIS.—Meeting December 16 at 8 p. m. at the Hotel DeSoto, St. Louis, Mo. Election of officers and Christmas party. Awarding of prizes for best short papers presented during year.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—Meeting January 20 at the Hotel Ansley, Atlanta, Ga. Speaker: Arthur Williams, assistant chief engineer, in charge of Research Division, The Superheater Company. Subject: Superheater Unit Research and Development.

NORTHWEST CAR MEN'S ASSOCIATION.—Meeting held December 1. Speaker: F. G. Moody, superintendent car department, Northern Pacific. Subject: Handling and Maintenance of Equipment in Connection with National Defense.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Meeting December 8 at 8 p. m. at the La Salle Hotel, Chicago. Speaker: V. R. Hawthorne, executive vice-chairman, Association of American Railroads. Subject: Keep the Wheels Rolling.

WESTERN RAILWAY CLUB.—Meeting held November 17. Speaker: Dr. Charles Copeland Smith, National Association of Manufacturers. Subject: The American Way.

EASTERN CAR FOREMAN'S ASSOCIATION.—Meeting December 11, Hotel Commodore, New York, at 1:30 p. m. Annual meeting for election of officers and directors.

Mid-west Air Brake Club To Hold May Meeting

During the first week of May, 1942, the Midwest Air Brake Club will hold a two-day meeting at Parsons, Kan. The program being arranged for this meeting is as follows:

The Four-Position Pressure Retaining Valve and Its Effect Upon Freight-Train Handling; also modification of present A. A. R. three-position retainers to four-position type, by W. E. Vergan, general air brake supervisor, M-K-T.

Visit to M-K-T shops at Parsons to view maintenance of AB brakes in detail and shop work in general.

Review of the development of the AB freight-car brake by Westinghouse Air Brake Company representatives.

Demonstration of the H-6-V brake valve, by W. E. Vergan.

Locomotive air equipment repairs and maintenance at M-K-T shops, Parsons.

Review of the development of the ET locomotive equipment; also a paper on A Method of Removing Oil and Water from Yard and Shop Compressed Air Plants, by New York Air Brake Company representatives.

DIRECTORY

The following list gives names of secretaries, dates of next regular meetings, and places of meetings of mechanical associations and railroad clubs:

ALLIED RAILWAY SUPPLY ASSOCIATION.—J. F. Gettrust, P. O. Box 5522, Chicago.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—C. E. Davis, 29 West Thirty-ninth street, New York. Annual meeting Hotel Astor, New York, December 1-5.

RAILROAD DIVISION.—C. L. Combes, *Railway Mechanical Engineer*, 30 Church street, New York City. Railroad Division sessions at annual meeting of society, Hotel Astor, New York, December 4.

MACHINE SHOP PRACTICE DIVISION.—Warner Seely, Warner & Swasey Co., 5701 Carnegie avenue, Cleveland, Ohio.

MATERIALS HANDLING DIVISION.—F. J. Shepard, Jr., Lewis-Shepard Co., Watertown Station, Boston, Mass.

OIL AND GAS POWER DIVISION.—L. N. Rawley, Jr., Power, 330 West Forty-second street, New York.

FUELS DIVISION.—D. C. Weeks, Consolidated Edison Co., 4 Irving Place, New York.

ANTHRACITE VALLEY CAR FOREMEN'S ASSN.—Frank Kramer, 412 Hill street, Duryea, Pa. Meets third Monday of each month at Wilkes-Barre, Pa.

ASSOCIATION OF AMERICAN RAILROADS.—Charles H. Buford, vice-president Operations and Maintenance Department, Transportation Building, Washington, D. C.

OPERATING SECTION.—J. C. Caviston, 30 Vesey street, New York.

MECHANICAL DIVISION.—A. C. Browning, 59 East Van Buren street, Chicago.

PURCHASES AND STORES DIVISION.—W. J. Farrell, 30 Vesey street, New York.

MOTOR TRANSPORT DIVISION.—George M. Campbell, Transportation Building, Washington, D. C.

CANADIAN RAILWAY CLUB.—C. R. Crook, 4415 Marcill avenue, N. D. G., Montreal, Que. Regular meetings, second Monday of each month, except June, July and August, at Windsor Hotel, Montreal, Que.

CAR DEPARTMENT ASSOCIATION OF ST. LOUIS.—J. J. Sheehan, 1101 Missouri Pacific Bldg., St. Louis, Mo. Regular monthly meetings third Tuesday of each month, except June, July and August, DeSoto Hotel, St. Louis.

CAR DEPARTMENT OFFICERS' ASSOCIATION.—Frank Kartheiser, chief clerk, Mechanical Dept., C. B. & Q., Chicago.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—G. K. Oliver, 8238 S. Campbell avenue, Chicago. Regular meetings, second Monday in each month, except June, July and August, La Salle Hotel, Chicago.

CAR FOREMEN'S ASSOCIATION OF OMAHA, COUNCIL BLUFFS AND SOUTH OMAHA INTERCHANGE.—H. E. Moran, Chicago Great Western, Council Bluffs, Ia. Regular meetings, second Thursday of each month.

CENTRAL RAILWAY CLUB OF BUFFALO.—Mrs. M. D. Reed, Room 1840-2, Hotel Statler, Buffalo, N. Y. Regular meetings, second Thursday of each month, except June, July and August, at Hotel Statler, Buffalo.

EASTERN CAR FOREMAN'S ASSOCIATION.—W. P. Dizard, 30 Church street, New York. Regular meetings, second Friday of January, February (annual dinner), March, April, May, October, and November at Engineering Societies Bldg., 29 West Thirty-ninth street, New York.

INDIANAPOLIS CAR INSPECTION ASSOCIATION.—R. A. Singleton, 822 Big Four Building, Indianapolis, Ind. Regular meetings, first Monday of each month, except July, August and September, in Indianapolis Union Station, Indianapolis, at 7 p. m.

LOCOMOTIVE MAINTENANCE OFFICERS' ASSOCIATION.—Secretary-treasurer C. M. Lipscomb, Missouri Pacific, North Little Rock, Ark.

MASTER BOILER MAKERS' ASSOCIATION.—A. F. Stiglmeier, secretary, 29 Parkwood street, Albany, N. Y.

MID-WEST AIR BRAKE CLUB.—C. F. Davidson, secretary-treasurer, general inspector car department, St. L.-S. F., Springfield, Mo.

NEW ENGLAND RAILROAD CLUB.—W. E. Cade, Jr., 683 Atlantic avenue, Boston, Mass. Regular meetings, second Tuesday in each month, except June, July, August and September.

NEW YORK RAILROAD CLUB.—D. W. Pye, Room 527, 30 Church street, New York. Meetings, third Thursday in each month, except June, July, August, September and December at 29 West Thirty-ninth street, New York.

NORTHWEST CAR MEN'S ASSOCIATION.—E. N. Myers, chief interchange inspector, Minnesota Transfer Railway, St. Paul, Minn. Meetings first Monday each month, except June, July and August, at Midway Club rooms, 1931 University avenue, St. Paul.

NORTHWEST LOCOMOTIVE ASSOCIATION.—G. T. Gardell, 820 Northern Pacific Building, St. Paul, Minn. Meetings third Monday of each month, except June, July and August.

PACIFIC RAILWAY CLUB.—William S. Wollner, P. O. Box 3275, San Francisco, Cal. Monthly meetings alternately in northern and southern California.

RAILWAY CLUB OF PITTSBURGH.—J. D. Conway, 1647 Oliver Building, Pittsburgh, Pa. Regular meetings, fourth Thursday in month except June, July and August, Fort Pitt Hotel, Pittsburgh, Pa.

RAILWAY FUEL AND TRAVELING ENGINEERS' ASSOCIATION.—T. Duff Smith, Room 811, Utilities Building, 327 South La Salle street, Chicago.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.—J. D. Conway, 1941 Oliver Building, Pittsburgh, Pa.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB.—A. T. Miller, P. O. Box 1205, Atlanta, Ga. Regular meetings, third Thursday in January, March, May, July and September. Annual meeting, third Thursday in November, Ansley Hotel, Atlanta, Ga.

TORONTO RAILWAY CLUB.—D. M. George, Box 8, Terminal A, Toronto, Ont. Meetings, fourth Monday of each month, except June, July, and August, at Royal York Hotel, Toronto.

WESTERN RAILWAY CLUB.—E. E. Thulin, executive secretary, Room 822, 310 South Michigan avenue, Chicago. Regular meetings, third Monday in each month, except June, July, August, September, and January.

(Turn to next left-hand page)

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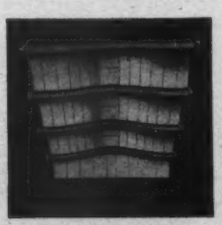
This foresight of the American Arch Company in adhering to standards is but one of the many ways in which the American Arch Company is serving the railroads.



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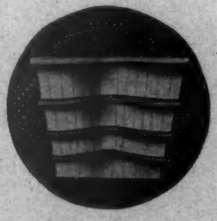

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NEWS

A. A. R. Lumber Specifications

At a joint meeting of the Car Construction Committee of the Association of American Railroads and representatives of the lumber manufacturers, the following six suggestions were advanced, not with the thought of making them mandatory or permanent practice, but simply for the duration of the present emergency and to help solve the problem of securing lumber required for new equipment and repairs:

(1) It is suggested that the demand for edge grain material be confined to sections requiring wearing material, and not be insisted upon for lining and interior roofing.

(2) Require edge grain or heartwood only for the kind of wood and for the part of a car where either is absolutely necessary.

(3) Some railroads order select grades for use in repairs instead of common grades as recommended in A. A. R. Specification M-907-33. Under present conditions that procedure is undesirable. The supply situation in the lumber industry possibly would be better served if the common grades were substituted for the select grades in the flooring, lining and inside roofing of repaired cars.

(4) As an emergency proposition only, on new and existing cars where it is possible, lining of double sheathed cars to be ordered in two pieces in varying lengths of six feet and up, and applied to suit nailing post spacing. This does not apply to single sheathed cars. In view of the present emergency this arrangement is brought to the attention of the individual railroads for such action as they see fit.

(5) The "Use Classification" on pages 4 and 5 of Specification No. M-907-33 provides for several kinds of wood suitable for each detail part. Because so many railroads have limited their acceptable woods it is suggested that, in view of the present emergency, mechanical officers give consideration to other suitable woods shown in the specification.

(6) Wherever it is practicable inspection to be made by authorized lumber inspectors at point of origin rather than at destination, also for railroads not equipped to make such inspection, that arrangements be made for such inspection by authorized inspectors of other railroads located in the vicinity of the district from which lumber is being shipped. The lumber manufacturers believe this will avoid rejections at destination. This arrangement might be agreeable to some railroads under the present emergency and is a matter for a decision of individual railroads.

President Approves Lease-Lend Measure

President Roosevelt has signed H. R. 5788, the new lend-lease bill. As pointed out in the November *Railway Mechanical Engineer*, page 498, the measure includes an item of $25,000,000 for railway equipment and facilities to be used in the Middle East "theatres of war." Hearings on the bill before the Senate appropriations committee fail to show any reference to this item in the upper house committee discussions.

The bill also includes an item of $69,385 for the National Mediation Board. Some $55,000 of this amount will be used to reimburse the board's arbitration-and-emergency-boards account, from which will come funds to pay the expenses of the five-man emergency board now considering the wage-increase demands. The $14,385 item will enable the board to employ two additional mediators and provide additional funds for travel expenses.

Milwaukee 5,400-Hp. Diesel-Electric Freight Locomotives

A 5,400-hp. Diesel-electric locomotive that has been delivered to the Chicago, Milwaukee, St. Paul & Pacific by the Electro-Motive Corporation, and has been placed in high-speed freight service between Avery, Idaho and Othello, Wash., a distance of 227 miles. The locomotive replaces steam locomotives formerly used between the two electrified sections of the railway, and makes a round trip daily.

The four units of the new Diesel are 193 ft. in length and weigh 856,000 lb. Each unit is equipped with a 1,350 hp. 16-cylinder engine. The starting tractive force is 220,000 lb.

The locomotive is equipped with automatic boilers for heating trailing cars if it should be used in passenger service, electric dynamic holding brakes, automatic air brake control, and audible and visual signals that indicate low lubricating oil pressure, hot engine water, hot journals, and wheel slippage.

Ceiling Prices for Low-Alloy Steel Castings

Prices for carbon and low-alloy steel castings, including "railroad specialties," are prevented from going above approximately current levels, through the issuance of a price schedule on November 14 by Leon Henderson, administrator, Office of Price Administration. The schedule, effective November 15, provides that the maximum prices shall be those that prevailed on July 15, 1941.

Except for railroad specialties, these maximum prices will approximate those contained in the "Comprehensive Report of Price Lists of Miscellaneous Castings," issued by the Steel Founders' Society of America for the third quarter of 1941.

Any miscellaneous castings for which prices are not determined by the "Comprehensive Report" are to sell at not more than the July 15 prices, according to the schedule. Special provision is made for pricing of castings not previously produced by a manufacturer. Roughly, the castings involved fall into two groups: Railroad specialties and miscellaneous. The first includes side-frames, bolsters, yokes and couplers, used in the running gear of railroad freight and passenger cars. The mis-

The new 5,400-hp. Diesel-electric freight locomotive recently delivered to the C. M. St. P. & P. by the Electro-Motive Corporation

cellaneous castings field takes in all manner of products. Steel scrap is the principal raw material in the production of carbon and low-alloy castings.

The new schedule provides that applications may be made to OPA to complete outstanding contracts at higher than ceiling prices in certain special instances. Sworn affirmations of compliance are required to be filed monthly.

Equipment Purchasing and Modernization Programs

Chicago, St. Paul, Minneapolis & Omaha.—This company has asked the Interstate Commerce Commission for authority to assume liability for $1,210,000 of equipment trust certificates, maturing in 10 equal annual installments of $121,000 on December 1 in each of the years from 1942 to 1954, inclusive. The proceeds will be used as part of the purchase price of equipment costing a total of $1,621,000 and consisting of 500 40 ft. 6 in. box cars.

Pennsylvania.—As part of its contribution to the national defense, the Pennsylvania is engaging in a most important and far-reaching program for the enlargement and improvement of its freight car supply. The program calls for the construction, during 1941 and 1942, of 11,876 new freight cars, and the complete reconditioning, by Class I heavy repairs, of approximately 3,000 cars per month. This will add 9,600 cars to the available supply by the close of the present year, and over 23,000 by October 1, 1942, just prior to the annual traffic peak. By that date, also, the proportion of freight cars under or awaiting repairs is expected to be reduced to 3.4 per cent, a minimum practicable working level.

The program also includes the building of 25 locomotives and heavy repairs to existing engines at the rate of 200 per month.

In the 12-year period from January 1, 1930, to the end of the present year, installations of new equipment on the Pennsylvania will have totaled over 35,000 freight cars and 336 locomotives. In the same period, the railroad has spent an aggregate of $667,500,000 on betterments, improvements and additions to its general facilities for rendering service.

The 3,000 repaired cars which the Pennsylvania is turning out of its shops each month are, according to the railroad, in every respect the equivalent of new cars from a service and utility standpoint. Only those parts are preserved in the repair process which are capable of giving results, substantially equivalent to new and, in addition, all improved and modernized features are applied.

Union Pacific.—The enginehouse facilities of the Union Pacific at Ogden, Utah, are being extended and rearranged at a total cost of approximately $109,000 to accommodate the new large locomotives recently placed in service in this territory. A contract in connection with this work, amounting to approximately $58,000 has been awarded the James Leck Company, Minneapolis, Minn. The work includes the construction of three track drop pits and a table.

Pullman Trial Begins at Philadelphia

ON November 3 the federal government inaugurated an anti-trust suit against the Pullman organization in the United States District Court at Philadelphia, Pa., before a special three-judge "expediting" court composed of John Biggs, Jr., H. F. Goodrich, and Albert Maris. The suit (Civil Action No. 994) was first filed on July 12, 1940, and refiled in amended form on July 22, 1941. It names as defendants Pullman, Inc., its wholly-owned subsidiaries, the Pullman Company (operator of sleeping car service), Pullman-Standard Car Manufacturing Corporation (car building unit) and Pullman Car & Manufacturing Corporation of Alabama (leases car manufacturing facilities to Pullman-Standard) and 31 directors and officers of these companies.

Allegations specified in the *amended*

(*Continued on second left-hand page*)

Orders and Inquiries for New Equipment Placed Since the Closing of the November Issue

Locomotives

Road	No. of Locos.	Types of Locos.	Builder
American Steel & Wire Co.	1	300-hp. Diesel-elec.	Whitcomb Loco. Co.
Arkansas Ordnance Plant	1	50-ton Diesel-elec.	General Electric Co.
Baltimore & Ohio	6	600-hp. Diesel-elec.	Electro-Motive Corp.
	4	1,000-hp. Diesel-elec.	
Belt Rwy. of Chicago	1	1,000-hp. Diesel-elec.	Baldwin Loco. Works
Chemical Warfare Arsenal	2	65-ton Diesel-elec.	General Electric Co.
Chesapeake & Ohio	10	2-6-6-6	Lima Loco. Works
Chicago & North Western	1	1,000-hp. Diesel-elec.	American Loco. Co.
	1	600-hp. Diesel-elec.	
Johns-Manville Service Co.	1	380-hp. Diesel-elec.	Whitcomb Loco. Co.
Litchfield & Madison	1	1,000-hp. Diesel-elec.	Baldwin Loco. Works
Lone Star Defense Corp.	2	65-ton Diesel-elec.	General Electric Co.
Macon, Dublin & Savannah	1	1,000-hp. Diesel-elec.	Baldwin Loco. Works
Mississippi Export	1	44-ton Diesel-elec.	General Electric Co.
New Orleans Public Belt	3	660-hp. Diesel-elec.	Baldwin Loco. Works
Pere Marquette	4	1,000-hp. Diesel-elec.	Electro-Motive Corp.
	1	600-hp. Diesel-elec.	
Richmond, Fredericksburg & Potomac	2[1]	660-hp. Diesel-elec.	American Loco. Co.
Southern Pacific	3	44-ton Diesel-elec.	General Electric Co.
Union Railroad	5	1,000-hp. Diesel-elec.	Electro-Motive Corp.
	2	1,000-hp. Diesel-elec.	American Loco. Co.
U. S. Navy Dept.	1	25-ton Diesel-elec.	Atlas Car & Mfg. Co.
	2	Diesel-elec.	General Electric Co.
	1	Diesel-elec.	Whitcomb Loco. Co.
U. S. War Dept.	20[2]	2-8-8-2	American Loco. Co.
Upper Merion & Plymouth	1	600-hp. Diesel-elec.	Baldwin Loco. Works
	1	80-ton Diesel-elec.	General Electric Co.
Weldon Springs Ordnance Plant	2	45-ton Diesel-elec.	General Electric Co.
Western Pacific[3]	8	600-hp. Diesel-elec.	American Loco. Co.

Locomotive Inquiries

Delaware & Hudson	10-15	4-8-4	.....
Pennsylvania	1	4,000-hp. Diesel-elec.	.....
U. S. Navy Dept.	1	Diesel-elec.	.....
U. S. Navy Dept., Bureau of Supplies and Accounts	1	Diesel-elec.	.....

Freight-Car Orders

Road	No. of Cars	Types of Cars	Builder
Bessemer & Lake Erie	425	90-ton hopper	Pull-Std. Car Mfg. Co.
	300	50-ton gondola	Greenville Steel Car Co.
	200	50-ton gondola	Pressed Steel Car Co.
Bethlehem Steel Co.	120[4]	50-ton gondola	Company shops
Central of New Jersey	50	70-ton cement hopper	American Car & Fdy. Co.
Chicago, Milwaukee, St. Paul & Pacific	5	70-ton gondola	Bethlehem Steel Co.
Lehigh Valley	1,000	50-ton coal	Bethlehem Steel Co.
Mathieson Alkali Works	6	50-ton box	American Car & Fdy. Co.
Pittsburgh & West Virginia	5	Caboose	Bethlehem Steel Co.
Wabash Car & Equipment Co.	25	70-ton covered hopper	American Car & Fdy. Co.

Freight-Car Inquiries

Aluminum Co. of America	100-200	70-ton hopper	.....
Mesta Machine Co.	6	70-ton gondola	.....
Mexico Northwestern	100	50-ton box	.....
National Rwys. of Mexico	200	50-ton tank	.....
Pittsburgh & West Virginia	100	50-ton box	.....
U. S. Navy Dept.[5]	101	50-ton box	.....
	61	50-ton flat	.....
U. S. Navy Dept., Bureau of Supplies and Accounts	10	50-ton box	.....
	15	50-ton flat	.....
U. S. War Dept.	25-75	20-ton flat	.....
	25-75	20-ton gondola	.....
	50-200[6]	Box	.....
	40[6]	Gondola	.....
	40[6]	Flat	.....
	25[6]	Comb. flat and caboose	.....

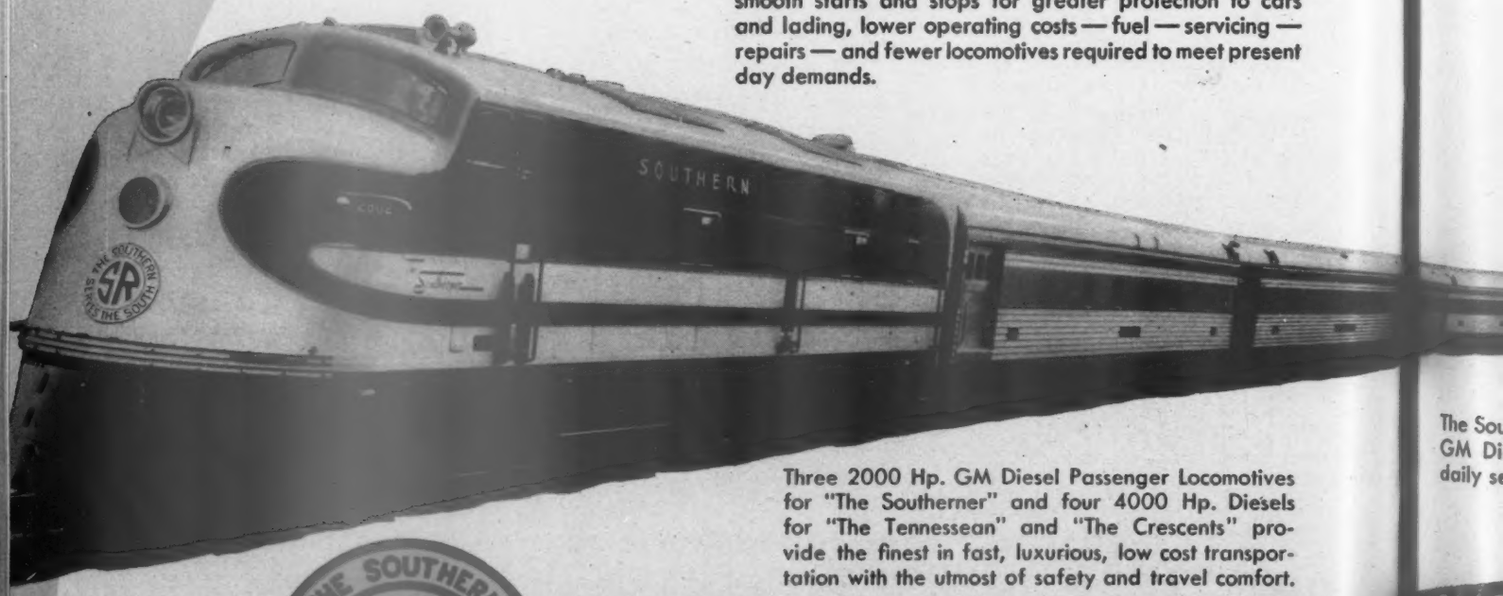
Passenger-Car Inquiries

Reading[7]		Streamlined	Pass.-Train Car Equipment

[1] For January, 1942, delivery.
[2] For the Yunnan-Burma Railway in China.
[3] Federal court permission received. For February and March, 1942, delivery. Cost, $485,000.
[4] For the company's own use.
[5] Army-Navy munitions board preference ratings of A-1-a and A-1-b assigned to this equipment.
[6] For export to China.
[7] Reported to be considering the acquisition of this equipment.

GM Diesels

GM Diesel Switchers deliver year round dependable service with greater starting effort, superior flexibility, high availability, more work output, greater safety, smooth starts and stops for greater protection to cars and lading, lower operating costs — fuel — servicing — repairs — and fewer locomotives required to meet present day demands.



Three 2000 Hp. GM Diesel Passenger Locomotives for "The Southerner" and four 4000 Hp. Diesels for "The Tennessean" and "The Crescents" provide the finest in fast, luxurious, low cost transportation with the utmost of safety and travel comfort.

THE SOUTHERN
SR
SERVES THE SOUTH

GENERAL MOTORS
LOCOMOTIVES

ELECTRO-MOTIVE
SUBSIDIARY OF GENERAL MOTORS

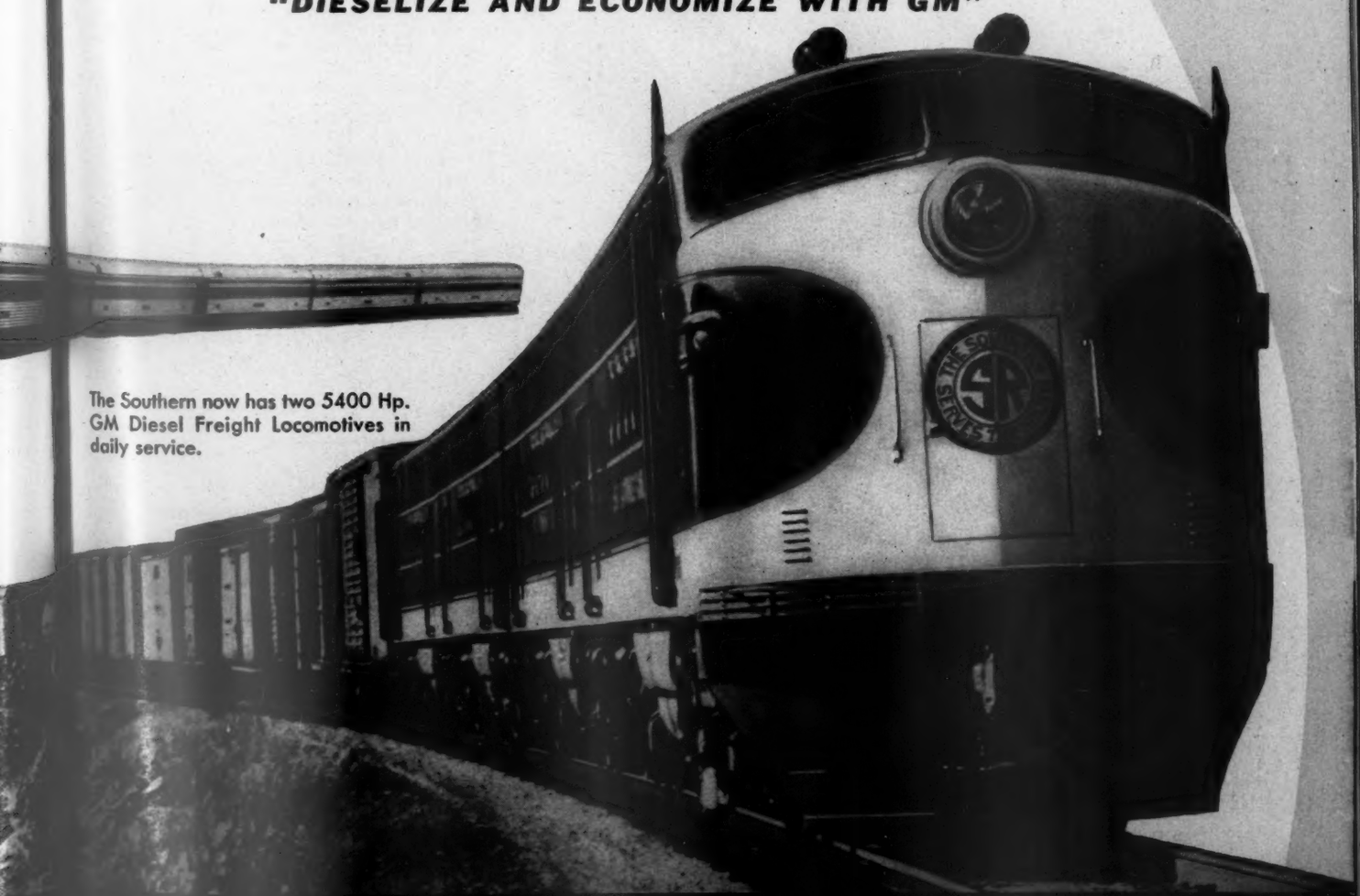
For All Services on the

SOUTHERN

THE SOUTHERN recently stepped into the lead as the first Eastern railroad to adopt GM Diesel freight locomotives and to use Diesel power for all classes of service.

GM Diesel freight Locomotives have already demonstrated remarkable reliability of performance, exceptionally high availability and the ability to haul greater tonnage on existing schedules or the same tonnage on faster schedules — resulting in marked reductions in operating costs . . . Never before in all railroad history has any type of motive power provided so many possibilities for greater operating efficiency and economies as the GM Diesel.

"DIESELIZE AND ECONOMIZE WITH GM"



The Southern now has two 5400 Hp. GM Diesel Freight Locomotives in daily service.

E CORPORATION

RS LA GRANGE, ILLINOIS, U. S. A.

complaint—all of which were categorically denied by Pullman—follow:

(1) Defendants have secured a complete and unlawful monopoly of the business of operating sleeping-car services in interstate commerce over the railroads of the United States;

(2) Prices and terms charged by the defendants to railroads for sleeping-car services have been non-competitive;

(3) Prices and terms charged by the defendants to the traveling public for services operated by the defendants have been non-competitive;

(4) The defendants have secured an absolute monopoly over the business of manufacturing sleeping cars;

(5) Defendants have unlawfully restrained competition in the manufacture, sale, lease and distribution of sleeping cars and other types of passenger equipment;

(6) Defendants have forced railroads to pay non-competitive prices for cars;

(7) Defendants have unlawfully coerced and restrained railroads in the operation of their businesses and have unlawfully forced railroads to refrain from responding to the forces of competition;

(8) Defendants have stifled competition in the manufacture, sale, lease, and operation of modern, light-weight, streamlined, high-speed trains and rolling stock, and defendants have unlawfully retarded the growth and development of a supply of modern passenger coach and sleeping cars in the United States.

Supply Trade Notes

THE AMERICAN SWEDO IRON CORPORATION, whose property was recently acquired by the present management, began operations on October 27 of this year. The company manufactures high-grade muck bars to specifications for staybolt, engine bolt and chain iron; low phosphorous melting bars; and skelp for pipe. The company's main office and plant are located at Danville, Pa., and a New York office maintained at 230 Park avenue, New York City. Harold T. Henry has been elected president and Eugene Brandeis, vice-president of the new company.

Obituary

DANIEL L. EUBANK, president of the D. L. Eubank Company, a railway supply sales agency, died at Atlanta, Ga., on November 24. Mr. Eubank was born at Churchville, Va., on November 24, 1869. He began his career in 1888 as a section laborer on the Chesapeake & Ohio and later served successively as locomotive fireman and engineman on that road until 1903. In that year he was appointed road foreman of engines. In 1911, Mr. Eubank left the railroad to become a service engineer of the Galena-Signal Oil Company and in 1919 was promoted to district manager of that company. In 1922, he was appointed its supervising service engineer, in which capacity he continued until 1932, when the business of the then Galena Oil Corporation was liquidated. He then established his own business as railway supply representative in which he was engaged at the time of his death.

D. L. Eubank

Mr. Eubank had long been active in organizations of railway and railway supply men. Since 1937, he had been the president of the Railway Supply Manufacturers' Association, the organization of exhibitors at Atlantic City in connection with the meetings of the A. A. R. Mechanical Division. He became a member of the executive committee of this organization in 1926 and served as vice president from 1930 to 1937. Mr. Eubank was formerly a member of the Traveling Engineers Association, and later belonged to the Railway Equipment Manufacturers' Association, the exhibiting organization associated with the T. E. A. He was president of this association in 1922. He had been treasurer of the Southern & Southwestern Railway Club since 1932.

◆

HENRY F. GILG, who was in the railway supply business in Pittsburgh, Pa., for a great many years, died on October 10. He was 82 years of age.

◆

A. H. HUDSON, sales agent for the American Car and Foundry Company, died on October 30, at Upper Montclair, N. J.

Personal Mention

General

FREDERICK T. H. JAMES, assistant to chief of motive power of the Delaware, Lackawanna & Western, has been promoted to chief of motive power, with headquarters as before at Scranton, Pa., to succeed Edward E. Root, who requested a leave of absence because of ill health. A photograph of Mr. James and a biographical sketch of his railway career were published in the July, 1941, *Railway Mechanical Engineer*, in connection with his appointment as assistant to chief of motive power at that time.

Shop and Enginehouse

A. G. WALDRUPE, general foreman on the Southern at Knoxville, Tenn., has been promoted to shop superintendent at that point.

J. J. VIEDEMAN has become erecting shop foreman on the Boston & Albany with headquarters at West Springfield, Mass.

WILLIAM J. MAYER, blacksmith shop foreman on the Michigan Central Railroad at West Detroit, Mich., was retired on pension October 31, 1941. Mr. Mayer started as a machinist, October 23, 1899, and was promoted to inspector in 1901, and to foreman of the blacksmith shop in August, 1902. For a number of years Mr. Mayer was Secretary of the Master Blacksmiths' Association.

Car Department

D. HENDRY, foreman of the freight car shops of the Canadian National at Transcona, Man., has been appointed superintendent of the car shops at Fort Rouge (Winnipeg), Man.

Master Mechanics and Road Foremen

R. T. HODGES, shop superintendent for the Southern at Knoxville, Tenn., has been appointed master mechanic with headquarters at Sheffield, Ala.

A. G. GEBHARD, trainmaster on the Illinois Central at McComb, Miss., has been appointed master mechanic-Diesel and electrical equipment, a newly created position, with headquarters at Chicago.

Obituary

ALFRED S. POE, resident inspector in the test department of the Baltimore & Ohio, with headquarters at Pittsburgh, Pa., died suddenly on November 10 at the age of 57 years.

WABCOTITE FIT

for *Main*

Here Also, They Insure...
Unbreakable, *Leakless* Joints

You've been realizing the advantages of non-breakable leak-proof Wabcotite Fittings on vital pipe joints of all devices in modern air brake equipments. Why not use them on main reservoir connections as well? They are available for application here also. Stopping of air leaks at these joints will help prevent an overworked compressor, lengthen its service life, and reduce possibility of it being the cause of costly train delays. Have Wabcotite Fittings applied to the main reservoirs of your next lot of locomotives. It will be a sure paying investment.

★

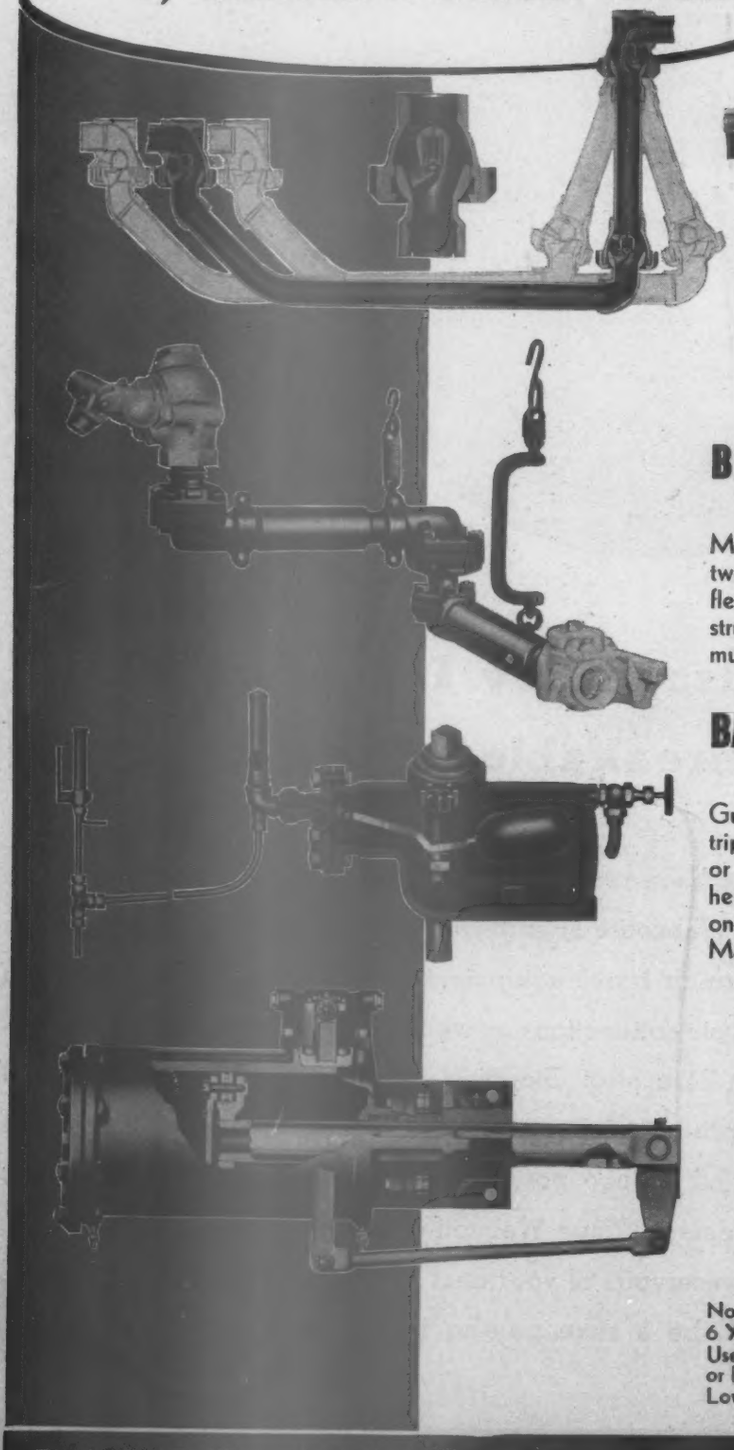
For every joint in any air brake equipment, where pipes unite, or branch, or attach to a device, there are suitable Wabcotite Fittings—tees, elbows, flanges, unions—available in a complete range of types and sizes. Among the thousands of these fittings now in service none has been known to break, leak, or require maintenance. » » »

WESTINGHOUSE...
AIR BRAKE COMPANY

WILMERDING, PENNSYLVANIA

BARCO PRODUCTS INCREASE

Comfort – Safety – Efficiency of Nation's Finest Trains



BARCO ENGINE TENDER CONNECTIONS

Bolted direct to Locomotive and Tender, require no manifolds — minimum number of 90° bends with steel wearing parts of alloy steel providing the utmost in safety, efficiency and low maintenance cost.

BARCO STEAM HEAT CONNECTIONS

For Passenger Cars and Rear of Tender

Metal wearing parts hardened alloy steel — only two wearing points per connection — maximum flexibility combined with simplicity and rugged construction provide maximum steam supply with minimum attention and lowest maintenance cost.

BARCO LOW WATER ALARM

Two-Whistle Float Type

Guards against engine failures — May be tested each trip in less than two minutes without any adjustments or disturbance of parts — Actuated solely by the height of the water above the crown sheet — depends on no other variables — Easy to Apply — Easy to Maintain.

BARCO POWER REVERSE GEAR

Provides the fine adjustment and precision-accurate control of locomotive valve motion essential to today's higher speeds. Maintains selected point of cut off — even a broken air supply pipe will not change the position.

BARCO UNIT TYTAMPERS

Now in Use on 78 Railroads.
6 Year's Satisfactory Service.
Used in Gang or Spot Tamping, Crib Busting or Breaking Ice or Frozen Ground or Cinders.
Low First Cost — Low cost of Maintenance.

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To get the most out of your power for lowest cost

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Flexible

STAYBOLTS

FLANNERY BOLT CO.

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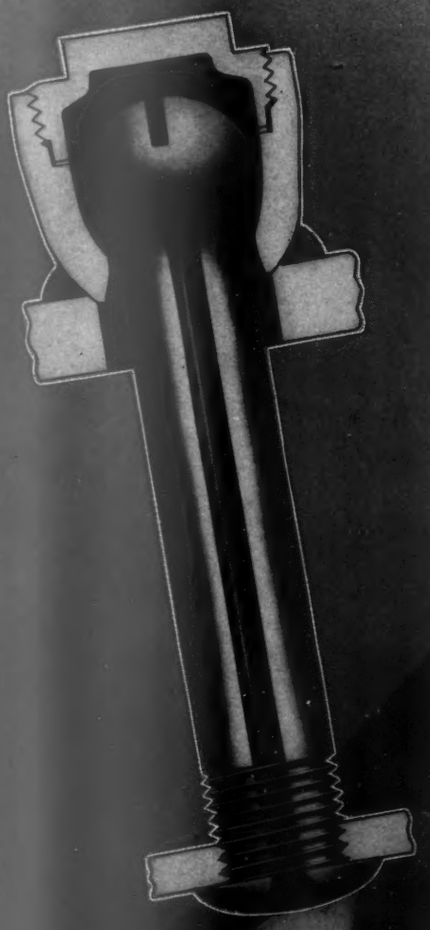

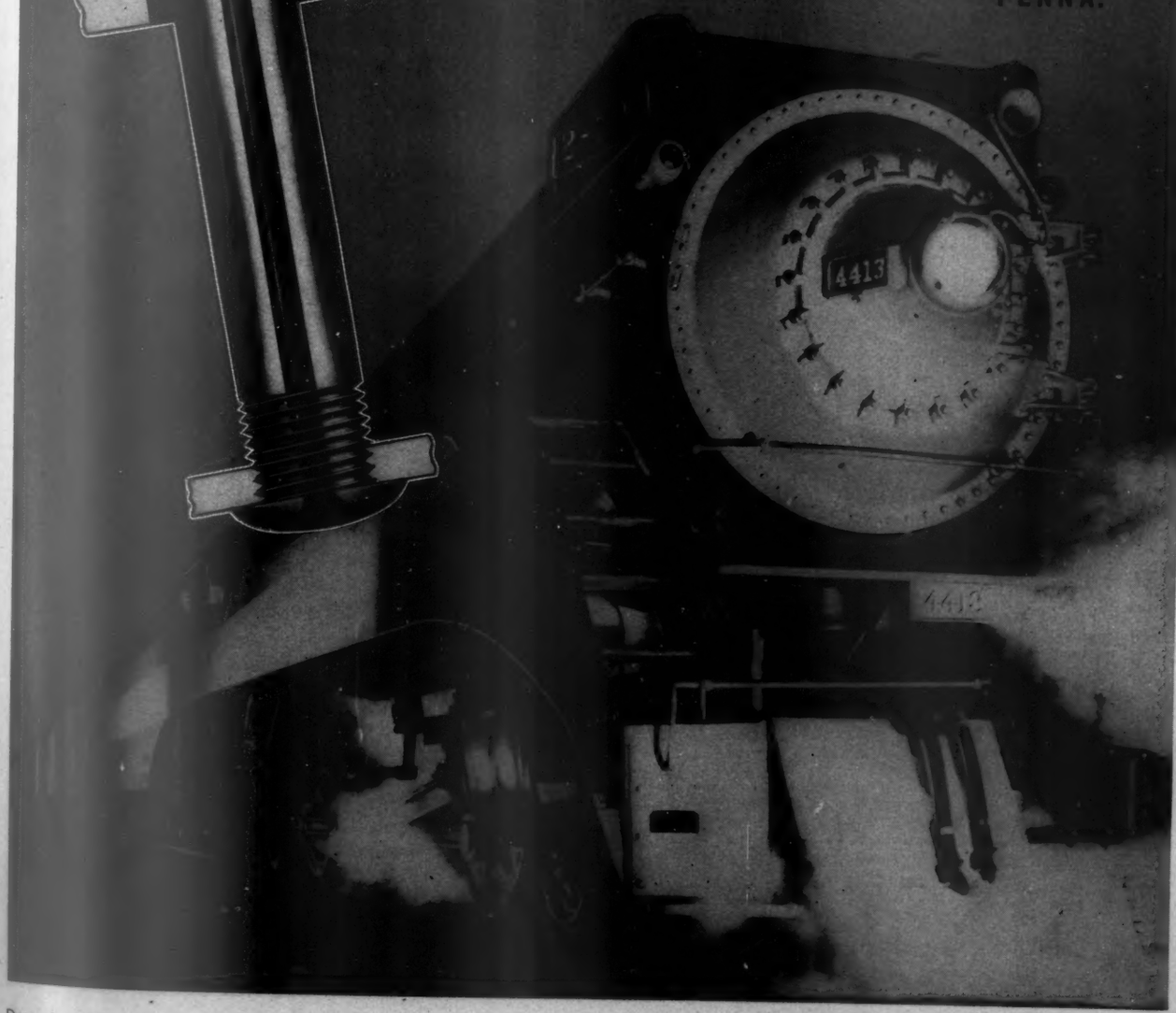

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FOR de-scaling cooling systems of Diesel locomotives in road and switching service, Oakite Compound No. 32 has been approved by many leading roads for THREE important reasons.

FIRST: Due to its uniform, controlled action, this specially designed material is SAFE... does not harm sound base metal surfaces. SECOND: It thoroughly, speedily removes insulating lime scale and rust deposits, restoring normal cooling efficiency to prevent engine overheating and other troubles due to impeded heat transfer. THIRD: Cost is low. FREE 20-page booklet gives complete, money-saving story.

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safely de-scaling Diesel
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RAILWAY SERVICE DIVISION
OAKITE PRODUCTS, INC. 46 Thames St. NEW YORK, N. Y.
REPRESENTATIVES IN ALL PRINCIPAL CITIES OF THE U. S. AND CANADA

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TRANSPORTATION LIBRARY

"Load 'em up and keep 'em rolling"

that's the kind of service COR-TEN Cars were built for!

OWNERS of Cor-Ten freight equipment have reason to pat themselves on the back today. For in their Cor-Ten cars they've got just the sort of equipment that's needed to meet the record-breaking rush of traffic that's ahead. Here is big-capacity equipment that can be loaded to the guards —that's new and modern to roll safely at passenger train speeds— that's tough and strong to keep on rolling.

There are 43,026 of these Cor-Ten freight cars in operation. Built from two to five tons lighter than conventional equipment they can carry an average of 2.56 tons more freight each. The 110,146 extra tons of carrying capacity they make available is equivalent to adding an extra 2,200 cars for freight hauling.

We ask you to watch the record that Cor-Ten cars are making in this emergency, and when you plan your car-building program, plan to use U·S·S Cor-Ten.

USS

UNITED STATES S

U·S·S
High Tensile Steels

AMERICAN STEEL & WIRE COMPANY,
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S STEEL

PROTECTION A

THE AMERICAN BRAKE SHOE A

N ALL ALONG THE LINE

Excessive brake head and key wear, "broken with part missing" brake shoe failures, lost keys and shoes, damage to wheels are all losses which can be minimized by using the Brake Shoe Lockey on your freight cars.

These important savings are possible because the Lockey holds head and shoe so tightly together that excessive wear is eliminated, while its locking feature prevents loss of keys through chattering brakes or on car dumpers.

Made of alloy spring steel, specially heat treated, the Lockey will not take a permanent set and may be used many times. Only a hand hammer is needed for application and removal.

Today's traffic needs make it more than ever essential to use every practical means to "keep them rolling", while metal shortages make it equally necessary to eliminate all sources of waste and loss. Brake Shoe Lockeys will help do both.

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BRAKE SHOE AND CASTINGS DIVISION

Commonwealth Products

CONTRIBUTE TO PASSENGER PROGRESS

FOR more than a third of a century Commonwealth Cast Steel Products for all types of railroad locomotives and cars have been constantly improved to meet the demands for better, more intensive service and greater availability.

Commonwealth devices for steam, Diesel and electric locomotives and passenger equipment contribute to greater safety at all speeds. Commonwealth trucks improve riding comfort and help make possible high-speed train operation.

More efficient performance and lower maintenance costs result from the use of Commonwealth Products.

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EDDYSTONE, PA. GRANITE CITY, ILL.

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THE LARGEST MANUFACTURER OF A COMPLETE LINE OF LATHES

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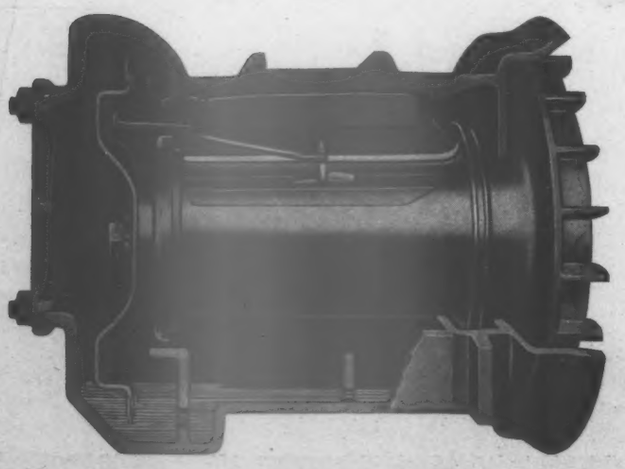
Nearly 12 years of maintenance saving service on multiple unit cars.



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Provide dependable oil film lubrication.
Retain oil level longer.
Exclude dirt and water.
Reduce lubricating attention.
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JONES & LAMSON 7-D SADDLE TYPE TURRET LATHE

A FAVORITE IN R. R. SHOPS

JONES & LAMSON turret lathes have always been favored by the machine tool supervisors in railroad shops.

Review of the purchases in recent years shows that the 7-D Saddle Type unit is the choice of most roads for bolt production jobs.

Naturally, there is a reason for this preference — the 7-D Saddle Type unit not only meets the precision requirements but also has many exclusive features which insure minimum cost of production.

Single lever speed and feed controls and coolant automatically delivered to the tools in the hexagon turret as they are cutting, are some of the many exclusive features that have earned the approval of every supervisor responsible for the cost of turret lathe production.

In spite of the heavy demands caused by the national emergency, Jones & Lamson engineers are ready to assist you with any problems in turret lathe production. Your request for assistance is no obligation.

Both illustrations show recent R. R. shop installations of Jones & Lamson 7-D Saddle Type turret lathes. One of the units replaced three lathes — the other is turning in over 50% saving over former production costs.

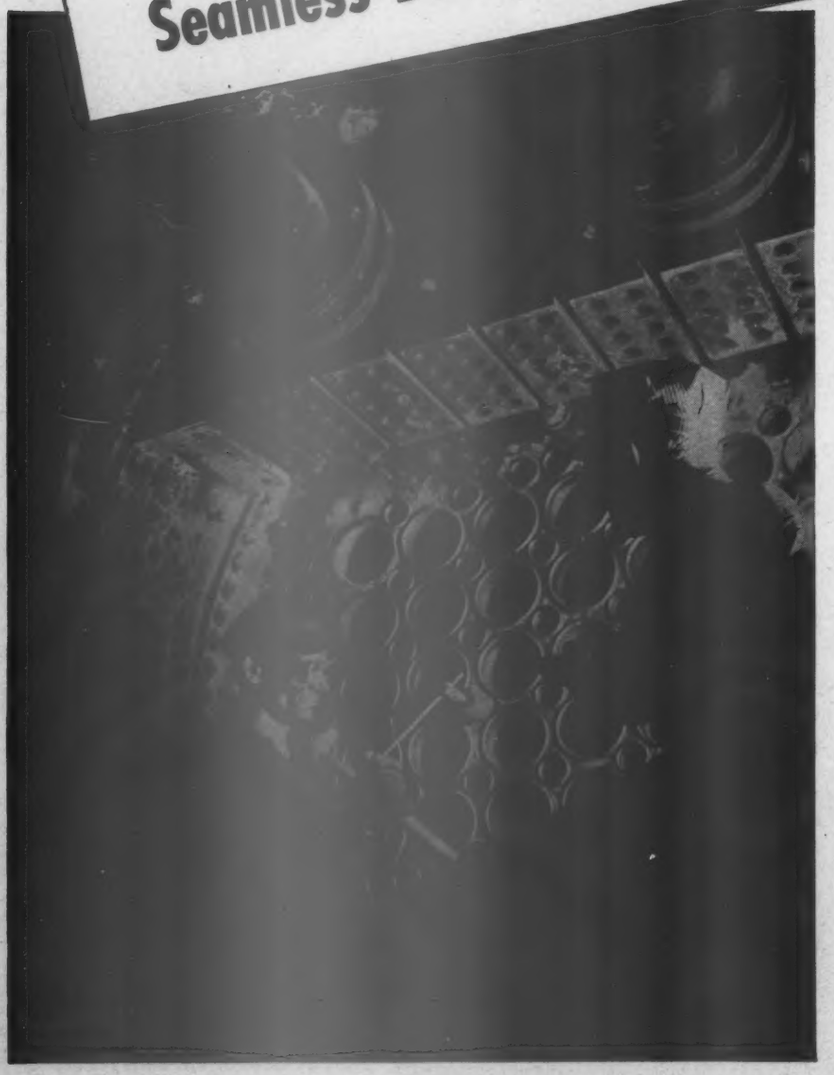
JONES & LAMSON MACHINE COMPANY

SPRINGFIELD, VERMONT

Manufacturers of: Ram and Saddle Type Universal Turret Lathes . . . Fay Automatic Lathes . . . Automatic Thread Grinding Machines . . . Comparators . . . Automatic Opening Threading Dies and Chasers.

"Busy days like these prove we were right about

NATIONAL Seamless Boiler Tubes"



WITH the railroads working on busier, faster schedules, repair jobs must be turned out of the shops in record time. It's no wonder that NATIONAL Seamless is the popular specification for locomotive boiler tubes these days. Ask any experienced railroad boiler mechanic — he'll tell you that they go in faster and stay in longer, that you can depend on saving between 15 and 20 per cent of the total installation time, and this applies equally to both new construction and re-tubing jobs.

NATIONAL Seamless Boiler Tubes save installation time because they are 100% annealed at the mill. This annealing provides the necessary balance between strength and ductility, and gives them exactly the right working qualities. It makes them just soft enough for easy installation and just hard enough for maximum strength.

NATIONAL Seamless Tubes are pierced from a solid billet of the highest quality "killed" open-hearth steel —every tube is a hollow cylinder with uniform wall strength throughout. They have no weld, no line of longitudinal weakness. Descriptive matter upon request.

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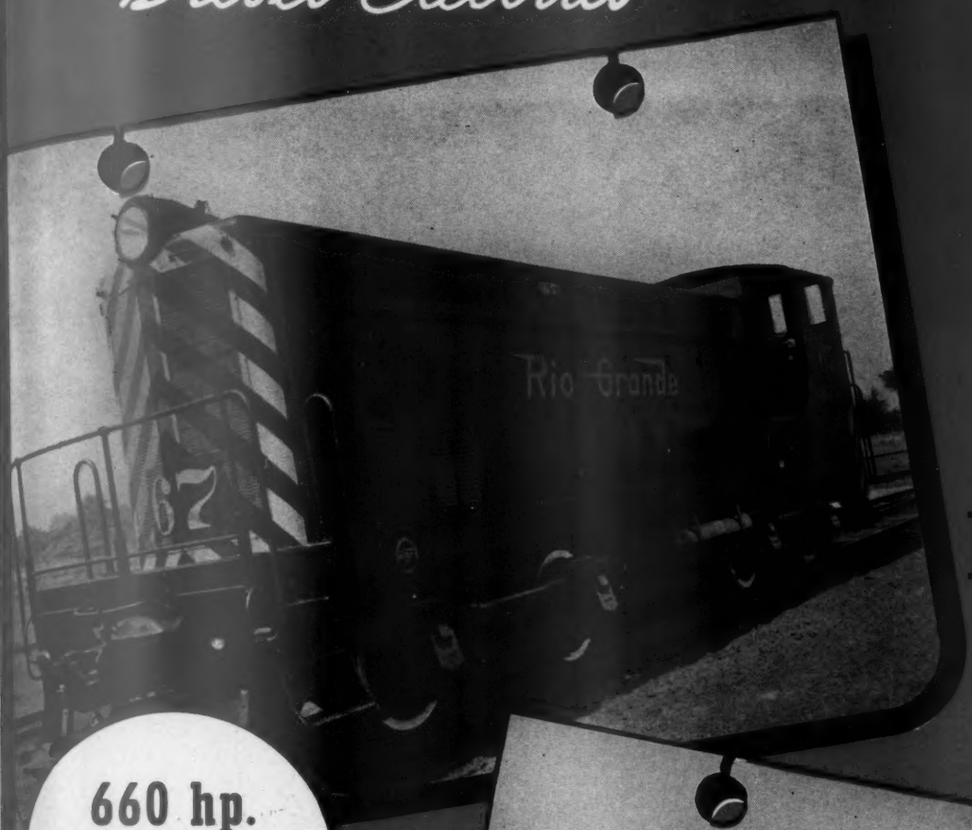
BALDWIN
Diesel-Electrics

2
CAPACITIES *to Meet Your* SWITCHING REQUIREMENTS

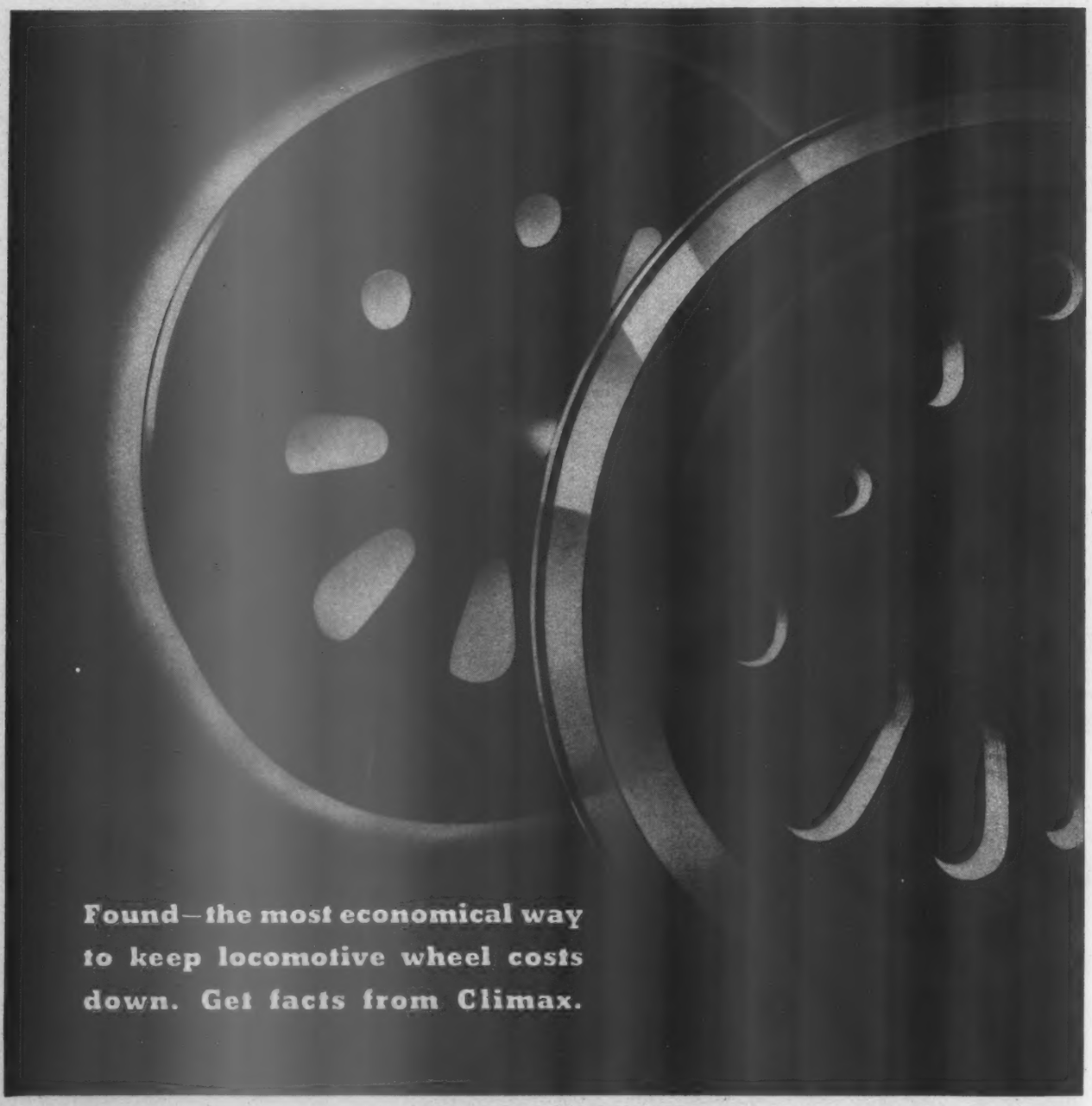


660 hp.
Baldwin DeLaVergne, 4-Cycle Diesel Engine. Westinghouse Electrical Transmission.

1000 hp.
Baldwin DeLaVergne, 4-Cycle Diesel Engine. Westinghouse Electrical Transmission.

BLW
THE BALDWIN GROUP

THE BALDWIN LOCOMOTIVE WORKS
Philadelphia



When increased operating speeds set up the serious problem of keeping wheel centers in round, railroads found casting them from Molybdenum Steels the complete and economical solution.

Both Chromium-Molybdenum and intermediate (1.0 to 1.50% Mn) Manganese-Molybdenum are used. Both develop strength that keeps wheel centers from getting out of round prematurely. Tire life is thus lengthened, locomotive shop time and expense reduced, and track maintenance costs held down.

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MOLY

"Tire Mill running OK nothing but praise for it"

SAID the Superintendent of Shops on one of the leading Railroads. He also offered to recommend this Tire Mill without reservation. He was talking about this new

Betts Tire Mill

Installed in their shops in June. If you need a tire mill you should see one of these new Betts Tire Mills because it will open up new possibilities to you for extreme accuracy and mirror like finish on any work you can handle on a machine of this size.

You will want to see one of these Mills in operation—write us.

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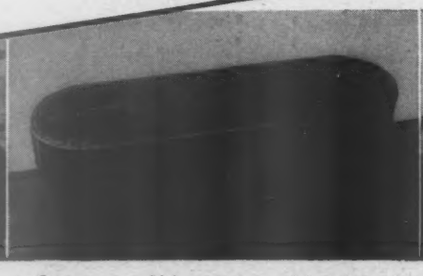
CONSOLIDATED
MACHINE TOOL CORPORATION
ROCHESTER, NEW YORK

HERE'S HOW TO BUILD THAT DRIVING BOX*

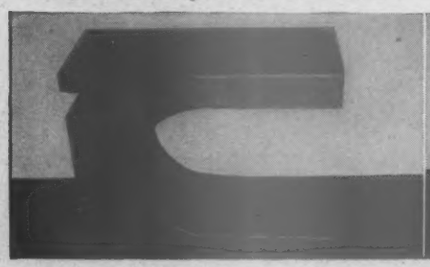
Cutting out driving box part with Airco Machine.

Two parts of driving box cut from one bloom.

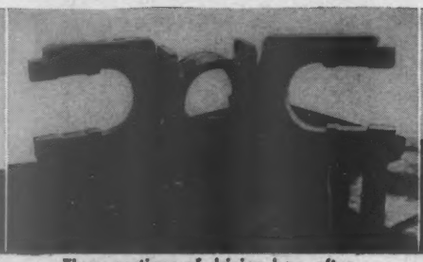


Center part which was removed is salvaged.

One of the two side pieces shown cut in Photograph 2.

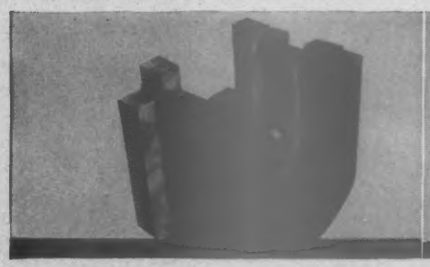


Next step—center piece cut out of a bloom.



Three sections of driving box, after being flame cut.

Center section of Photograph 6 veed ready for welding.



Three sections after veeing, now tack welded.

Driving box completely welded.

Fabricated driving box—bored, ready for brass.

To avoid costly delay brought about by slow delivery of vital replacement parts, many railroads are now equipped to build what they want whenever the need arises with Airco oxyacetylene and electric arc equipment. Fabrication costs are low — the time required in some instances — surprisingly fast. » » » If you are not fully aware of the unusual opportunities available to those roads equipped with the necessary apparatus, write for the whole story today.

***Many other replacement parts on which slow deliveries mean costly delay can also be fabricated easily and quickly with the same, simple Airco equipment used in the fabrication of this driving box.**

Air Reduction

General Offices: **60 EAST 42nd ST., NEW YORK, N. Y.**

IN TEXAS

MAGNOLIA-AIRCO GAS PRODUCTS CO.

AIRCO DISTRICT OFFICES IN PRINCIPAL CITIES

AIRCO WILSON

SERVING RAILROADS FROM COAST TO COAST

Just 1 of Dayton's 4 Big Extras

GET Daytons AND GET THESE 4 Big Extras

EXTRA SAVINGS in batteries you never buy.

EXTRA SAVINGS in maintenance man-power released for other work.

EXTRA SAVINGS in battery recharging.

EXTRA SAVINGS through protecting your good will (and revenue) from satisfied passengers.

PROMINENT RAILROAD SAVES THOUSANDS OF DOLLARS YEARLY ON BATTERY RECHARGING

"D-R" one-inch V-Belt Car Lighting Drive

$280 savings per car per year—that's important money in the face of today's rising operating costs. And it amounts to thousands of dollars annually when you multiply it by the number of cars operated by one prominent railroad.

That's what this railroad saves annually on battery recharging alone since it switched to Dayton 1" V-Belt Car Lighting Drives. What's more, these dependable, all-weather drives replaced belts which failed to last an average of one round trip in bad weather.

Dayton V-Belt Car Lighting Drives deliver trip after trip of trouble-free performance under all weather conditions. Battery life is longer . . . maintenance and service costs greatly reduced. Auxiliary equipment is protected because Daytons deliver constant, dependable power.

Unmatched for safe, economical performance, Dayton V-Belt Car Lighting Drives deliver the four big extra dividends of savings which more than pay for the cost of the drives themselves. Why accept less than the extras that only Dayton Drives deliver?

THE DAYTON RUBBER MFG. COMPANY
DAYTON, OHIO
Pioneers of Railway V-Belts and Connectors

Dayton

"D-R" V-BELT AXLE DRIVES
AND ENDLESS COG-BELT DRIVES
FOR CAR LIGHTING AND AIR CONDITIONING EQUIPMENT

Made by the World's Largest Manufacturer of V-Belts

Copyright 1941, The Dayton Rubber Mfg. Co.

GREATER PASSENGER COMFORT

with

Sturtevant

REG. U. S. PAT. OFF.

Air Conditioning

MORE UNIFORM TEMPERATURE AND HUMIDITY

HERE IT IS! A unique combination of equipment engineered by Sturtevant to provide closer control and greater operating economies in railway air conditioning.

THESE PROBLEMS ELIMINATED

1. Continual starting and stopping, frequent full load cycling *eliminated.*

2. Continual fluctuations of temperature and humidity *eliminated.*

THESE ADVANTAGES ASSURED

1. Variable output of Compressor-Condenser unit responds automatically to varying load demands.

2. Divided evaporator coils always operate at low temperatures—hold humidity within the comfort zone regardless of outside conditions.

WITH THESE RESULTS

1. Far greater comfort for passengers.

2. Less wear and tear on equipment—less maintenance.

3. Power savings when system operates at less than full load.

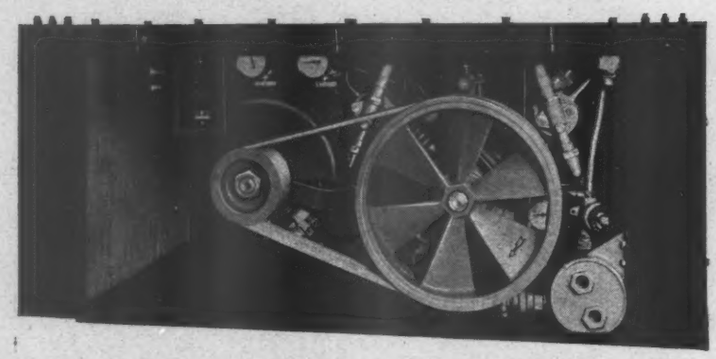
The regular type of units shown can be supplied with or without such features as—100% by-pass valve for charging car batteries, proportionally divided evaporator and 50% unloading valves on the compressor. Ask our nearest office for full information.

B. F. STURTEVANT COMPANY
Hyde Park, BOSTON, MASS. *Branches in 40 Cities*
B. F. Sturtevant Company of Canada, Ltd.
Galt, Toronto, Montreal

Sturtevant *Puts Air to Work*

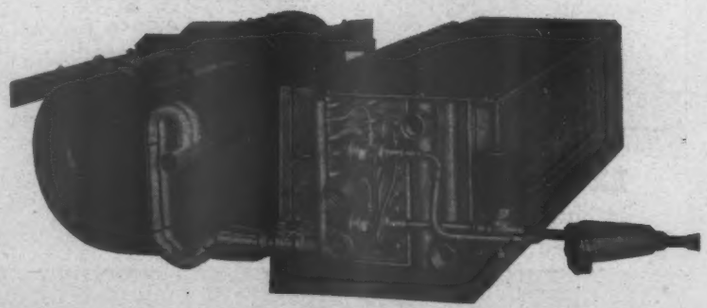
CHECK THE *improved* PERFORMANCE of these STURTEVANT UNITS

STURTEVANT *Compressor-Condenser*



Frequent off-cycling eliminated on this Compressor-Condenser by unloading valves which cut in or cut out one half of compressor cylinders—depending on the demand for refrigeration.

STURTEVANT *Fan-Evaporator*



Constant removal of moisture assured by automatically closing one half of divided Evaporator on light loads, switching to full capacity when cooling load increases.

THE 3-POWER FORMULA

...your surest road to profits

Alco

GE

Put EACH TYPE to Work Where It's Economically Best Suited

A Statement of Policy

THE policy of the American Locomotive Company and the General Electric Company is to work together on all problems of railroad motive-power application. American Locomotive has been manufacturing steam railroad motive power for a century. General Electric has been building electric locomotives for fifty years. Together we are also engaged in the manufacture and sale of diesel-electrics.

These factors place us in the happy position of being able to consider all types of motive power impartially and to recommend the type that is economically best suited to any particular application.

D. W. Brasser
PRESIDENT
AMERICAN LOCOMOTIVE COMPANY

C. E. Wilson
PRESIDENT
GENERAL ELECTRIC COMPANY

STEAM

With the Alco "Big Boy" setting the pace —steam is pulling for profits better than ever!

THERE are places where a modern steam locomotive can do a better money-making job than anything else—places where its cost and availability characteristics are economically best suited to do the job.

Steam power is pulling many of America's most famous and most profitable trains. Impartial surveys by our two companies produce the facts to show where steam can be put to work doing an even bigger job. American Locomotive built its first steam locomotive 100 years ago, and today has more steam power in service than any other manufacturer.

Right now—among many others—the 30 largest steam locomotives ever built are rolling from its shops. They—like every other modern Alco product—have what it takes to make money.

DIESEL-ELECTRIC

The newest money-maker — and Alco-G.E. units are showing how much the diesel-electric can earn!

BUILT to be kept busy, the high availability of a diesel-electric is evidence of the way it can keep on the job. This ability makes possible faster schedules with fewer locomotives and fewer servicing facilities.

The first Alco-G.E. diesel-electric was built in 1925. It is the forerunner of hundreds of Alco-G.E. switchers that are proving you can't beat diesel-electrics on a switching job.

Switching is a round-the-clock job, and the exceptional availability of an Alco-G.E. switching fleet enables it to get more work done and at less cost.

On the mainline, operators are showing what the diesel-electric's speed can do in turning profits upward. They are finding the public likes the diesel-electric ride, and that these modern giants, within the limits of their self-generated power, are taking advantage of electric drive's high availability, economy, and long life.

ELECTRIC

— Moving dense traffic at high schedule speeds, the electric keeps on setting top performance records!

THE electric locomotive is supreme in dense-traffic service. Its overload capacity enables it to exert power considerably in excess of its continuous rating for short periods of time. Therefore, by accelerating rapidly and negotiating relatively short grades on a rolling profile at sustained speeds, the electric moves the most tons per hour. This same overload capacity permits longer, heavier trains. Low maintenance, high availability, low power costs, and interchangeability between passenger and freight service combine to get the job done at lowest cost with the fewest locomotives.

In mountain operation, the extra pulling power and the regenerative braking of electrics make possible faster schedules both up grade and down. And they provide the only smoke-, gas-, and dirt-free power for tunnel operation.

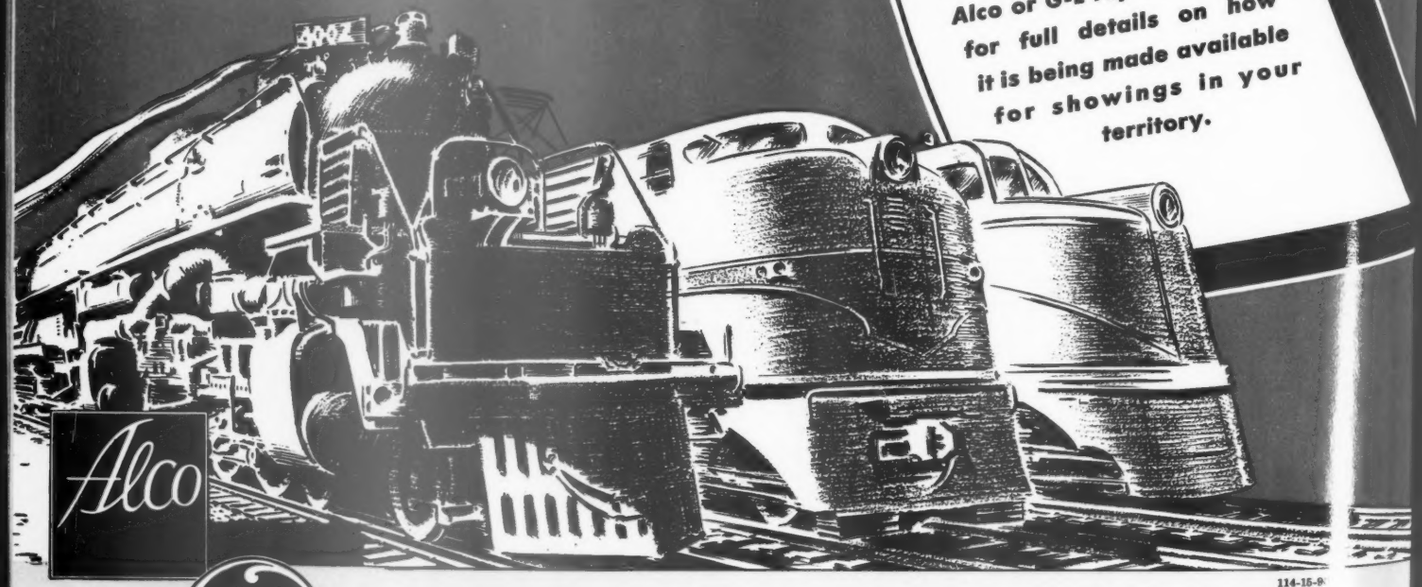
BEFORE YOU BUY NEW MOTIVE POWER

TAKE ADVANTAGE OF THE IMPARTIAL ADVISORY SERVICE ALCO AND G.E. CAN GIVE YOU

WE'LL be glad to help you survey your system to find the type of power—steam, electric, or diesel-electric—that is economically best suited to your needs. And in each type of power we can furnish equipment to do the job right.

We've been building motive power to meet your needs for 100 (Alco) and 50 (G.E.) years. Why not test the value of that experience? Get in touch with either your Alco or your G-E representative.

HAVE you seen the new Alco-G.E. full-color-and-sound motion picture, RAILROADIN'? Ask your Alco or G-E representative for full details on how it is being made available for showings in your territory.



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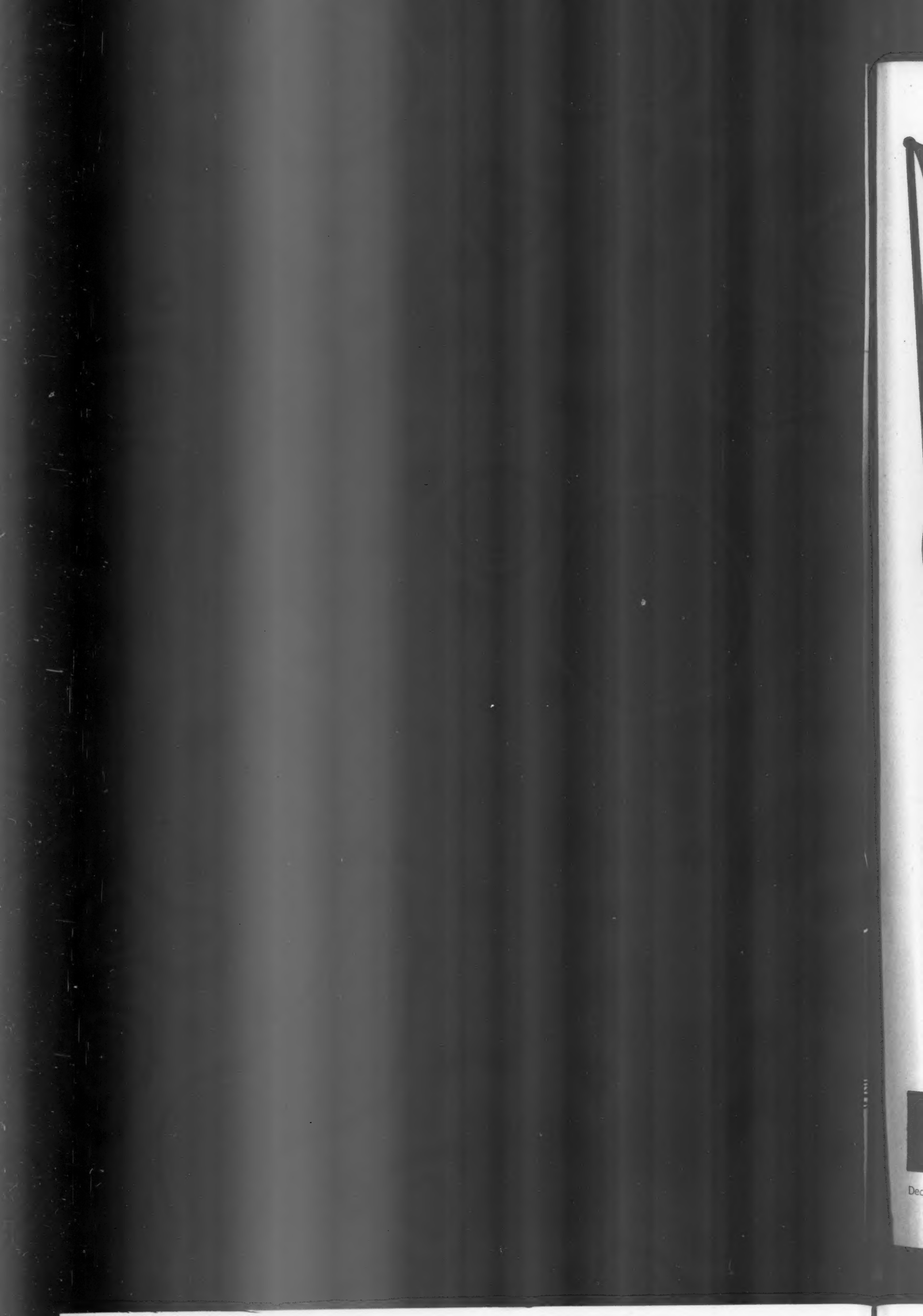
Working Side-by-Side to Save You Money

AMERICAN LOCOMOTIVE and GENERAL ELECTRIC



BARBER STABILIZING OF TRUCKS ASSURES REAL PROTECTION AT ALL SPEEDS!

Prepare your new and rebuilt cars for DEFENSE SERVICE . . . give them the *smooth, easy riding qualities* that mean *utmost protection* to cars and lading.

Barber-Stabilizing permanently eliminates all looseness between bolsters and columns by means of large, sturdy friction elements built into the bolsters.

The resulting tightness reduces the destructive bouncing action of the spring nest to a soft, stabilized cushioning action, *thereby eliminating countless damaging shocks to cars and lading at all speeds.*

Specify Barber-Stabilized Parts for GREATER SAFETY and PROFIT.

Over 52,000
CAR SETS
of STABILIZED TRUCKS

Giving Satisfactory Service On Forty-Three Roads and Private Car Lines.

Designed For Use With or Without Spring Planks and With or Without Lateral Motion

STANDARD CAR TRUCK COMPANY
332 SOUTH MICHIGAN AVENUE CHICAGO, ILLINOIS

TO THE RAILROAD OFFICIALS OF AMERICA...

We Have Witnessed the Part Speed Plays in the Modern "Blitzkrieg." Why Then Should Not Similar Speed Be Applied To Railway Freight?

SPEEDY MOVEMENT of freight is an absolute essential to the successful fulfillment of our entire National Defense Program.

Yet the possibility of a serious freight congestion exists, despite the fact that railroads are doing a magnificent job in handling more freight, with fewer cars, than in previous peak years.

Freight congestion can form a highly dangerous bottleneck to all of our Defense activities.

The solution to the problem lies simply in the adoption of "one-speed" railroading, with freight trains traveling at the speed of passenger trains.

Incorporate in freight cars, the same engineering principle that has made possible the speed of our modern streamliners and locomotives—the adoption of roller bearings.

Higher speeds and heavier loads simply are not possible with freight cars, so long as they use plain friction bearings.

Roller Bearings reduce starting resistance of individual cars 88 per cent; cut maintenance costs; increase life of equipment; eliminate hot-box delays; improve fuel economy; increase hauling capacity; make possible fast, on-time schedules; reduce claims for damage to lading; greatly reduce in-shop-for-repair time.

Now is the time to bring "blitzkrieg" methods to the speeding-up of freight shipping—to do away with obsolete equipment in railroading as in every other phase of National Defense.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

RAILWAY ROLLER BEARINGS

TIMKEN BEARING EQUIPPED

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

EVEN STEEL
CAN BECOME TIRED!

• Exhaustion in steel? Don't smile—ask a metallurgical engineer. He'll tell you that it's a very serious problem—for fatigue in steel may mean failure, disaster, financial loss.

Something had to be done about it—something was done—by Republic, world's largest producer of alloy steels.

New and better alloy steels, developed by Republic, provided greater strength and toughness—higher creep properties—uniform response to heat treatment—resistance to fatigue. As a result, freight and passenger traffic speeds to its destination—faster than ever before, in greater safety, with lower equipment maintenance cost.

Wherever high strength-weight ratio, hardness, toughness and *resistance* to corrosion are needed to extend life of vital working parts—wherever *resistance* to failure-inviting exhaustion is essential—the answer is a Republic Alloy Steel.

RESEARCH WILL NOT STOP!

One of our most important activities at Republic always has been research. Today's emergency has not retarded this work. On the contrary, it has greatly intensified our efforts.

We are carrying on a relentless and unceasing program directed toward the development of new steels for certain critical defense problems and the improvement of present steels.

Laboratory and plant research, commercial market research, product development research—all are exploring every possible avenue which may lead to *better* Republic steels for you in the future.

R. J. Wysor
PRESIDENT

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REPUBLIC *Alloy Steels*

MODERN DUFF-NORTON JACKS ...HELP YOU Speed up YOUR REPAIR and MAINTENANCE SCHEDULES

As a vital element in our defense program, Industry looks to the Railroads to keep things moving. And so, throughout the railroad industry, "SPEED" is the word of the day! In roundhouses and car shops everywhere, Duff-Norton Jacks are helping make new records in the repair and maintenance of rolling stock.

Husky Duff-Norton Jacks are easy to move and spot, easy to operate, fast raising and lowering, economical and absolutely safe and dependable.

Put Duff-Norton Jacks to work in your shops, and speed up your repair and maintenance schedules. We'll be glad to rush you full information on the complete line of modern, efficient Duff-Norton Jacks.

"THE HOUSE THAT JACKS BUILT"

THE DUFF-NORTON MANUFACTURING CO.
PITTSBURGH, PA.
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TIME IS SHORT

★

• Time is short—a nation arming against aggression has none to spare. But fast as the seconds tick, the hammers at Williams keep forging; turning out a ceaseless stream of the tools our country needs. To this course we are pledged; to this end we labor 'round the clock. But as we work, our search for better ways and greater skill continues. Time is short, but all of it is being used at Williams.

★

J. H. Williams & Co., 225 Lafayette St., New York

WILLIAMS

SUPERIOR DROP-FORGED TOOLS

Headquarters
for over half a century for
DROP-FORGINGS and DROP-FORGED TOOLS

STOP WHEEL FAILURE BEFORE IT STARTS!

• It's small wonder that entirely new standards of safety for high-speed, heavy-duty service are found in the ARMCO Stress-Resistant Wheel. It stops failure before it starts and does it without losing an inch of mileage performance.

ARMCO engineers worked more than five years developing this new kind of wheel—finding the cause of wheel failures—inventing a laboratory machine to simulate actual service conditions—testing steels—combining chemistry and processing methods.

The result is a wheel that *starts* life with the lowest possible internal stress. It strongly resists stresses built up in service. It has more resistance to thermal cracking than any other wheel. Shelling is reduced to a minimum. In the laboratory as well as in actual service the ARMCO Stress-Resistant Wheel has demonstrated its ability to withstand conditions much more severe than any other wheel ever withstood.

Regular ARMCO Heat Treated Wheels also benefited. These too have extremely low internal stresses and are exceptionally tough. And by a special process all ARMCO Wheels have easily machinable hubs to permit a true taperless bore.

Ask the ARMCO man about the application of Stress-Resistant Wheels to your needs. He'll gladly give you all the data you require. Armco Railroad Sales Co. Incorporated, 3001 Curtis St., Middletown, Ohio. Offices in principal cities.

ARMCO ARMCO **STRESS-RESISTANT WHEELS**

ANOTHER ARMCO CONTRIBUTION TO RAILROAD PROGRESS

Baker Elevating Truck pulling out car truck for repair.

Baker Low-Lift Truck with a 5200 lb. skid-load of journal brass.

Baker Crane Truck removing stoker from tender for repair.

BAKER TRUCKS *step up material handling efficiency*

Removing air compressor with a Baker Crane Truck.

Baker Low-Lift Truck specially built for handling LCL containers.

Baker Crane Truck applying car frame to wheels.

Baker Platform Truck carrying baggage and express in a [illegible] terminal.

● Railroads, faced with the immediate problem of gearing their activity to the increased demands of the Defense Program, are finding the solution in mechanizing material handling with Baker Trucks. Maintenance work in shops is speeded up by faster removal, transportation and application of heavy parts. Stores are making faster deliveries to yards, shops and stations. Terminals are handling freight and baggage in a fraction of the time formerly required.

● *Let the Baker representative near you show how Baker Trucks can be used to best advantage on your road. Or write us direct.*

BAKER INDUSTRIAL TRUCK DIVISION
of the Baker Raulang Co.
2172 WEST 25th STREET • CLEVELAND, OHIO

Baker Utility Truck servicing air-conditioned Pullman cars.

Removing side rod with Baker Crane Truck, using auxiliary boom.

Baker Hi-Lift Truck makes this awkward job simple and quick.

Baker Truck loads 45 kegs of nails into box cars at one trip.

Baker 3-wheel Tractor pulling a 12 trailer train in a freight terminal.

I-R

Baker INDUSTRIAL TRUCKS

In Canada: Railway and Power Engineering Corporation, Ltd.

MODERN FLOORS of ARMSTRONG'S LINOLEUM help Chicago Great Western streamline old coaches

One of the modernized coaches of Chicago Great Western Railway Company. Armstrong's Gray Marbelle Linoleum is installed under the seats and in the aisle, with a Linostrip of Armstrong's Ruby Plain Linoleum. The old magnesite floors were leveled and then primed with Armstrong's Asphalt Primer, and the linoleum was laid with Armstrong's Cement. Dependable service is thus assured.

CHICAGO Great Western, like other progressive railroads, know the importance of selecting the right floor in modernizing old coaches. They chose Armstrong's Linoleum because this floor has proved its superiority on three important counts:

1. BEAUTY—Armstrong's Linoleum comes in a wide range of colors and patterns that harmonize with practically any interior color scheme. Special designs and trademarks can be inset at modest cost.

2. LONG WEAR—Tramping, scuffing feet fail to dim the beauty of Armstrong's Linoleum because the colors are inlaid full depth in the material. Here's a floor that will stand up for years—even in heavy traffic areas.

3. LOW-COST MAINTENANCE—Daily sweeping and occasional washing with Armstrong's Floor Cleaner are all that's needed to keep Armstrong's Linoleum looking like new for years. Expensive refinishing is never necessary.

Armstrong's Complete Service

To help you get maximum efficiency from your flooring installations, Armstrong provides the following products: Cork Base Subflooring (lightweight, resilient, practically unaffected by temperature changes), Waterproof Adhesives, Asphalt Primer, and Cork-and-Rubber Anti-Squeak Tape. In addition, Armstrong offers Linowall—a colorful, durable, washable linoleum-type composition for walls and wainscoting.

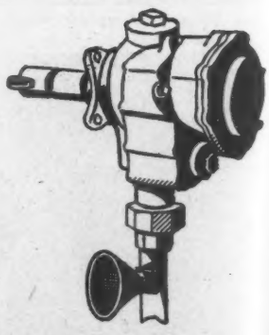
Turn to "Floor Headquarters" for your complete flooring needs. Get all the details of Armstrong's complete line of hard-surface transportation floors from your Armstrong representative, or write to Armstrong Cork Company, Industrial Division, 1244 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S FLOORS

LINOLEUM • LINOTILE (OIL-BONDED) • RUBBER TILE

Passenger traffic and passenger revenues are rising sharply. As the National Defense Program increases its tempo, the demand on passenger equipment will increase.

Superior Automatic Soot Blowers will help you "Keep 'em rolling". Protect your future passenger traffic. Keep your motive power out of the shop and in action. Save time, labor and expense with Superior Soot Blowers. They will save their cost in labor, arch brick replacement, shop time and fuel.



Superior Automatic Soot Blowers are quickly and easily installed. For proof of the statements made here and for quotations on your requirements write us today.

SUPERIOR RAILWAY PRODUCTS CORP.
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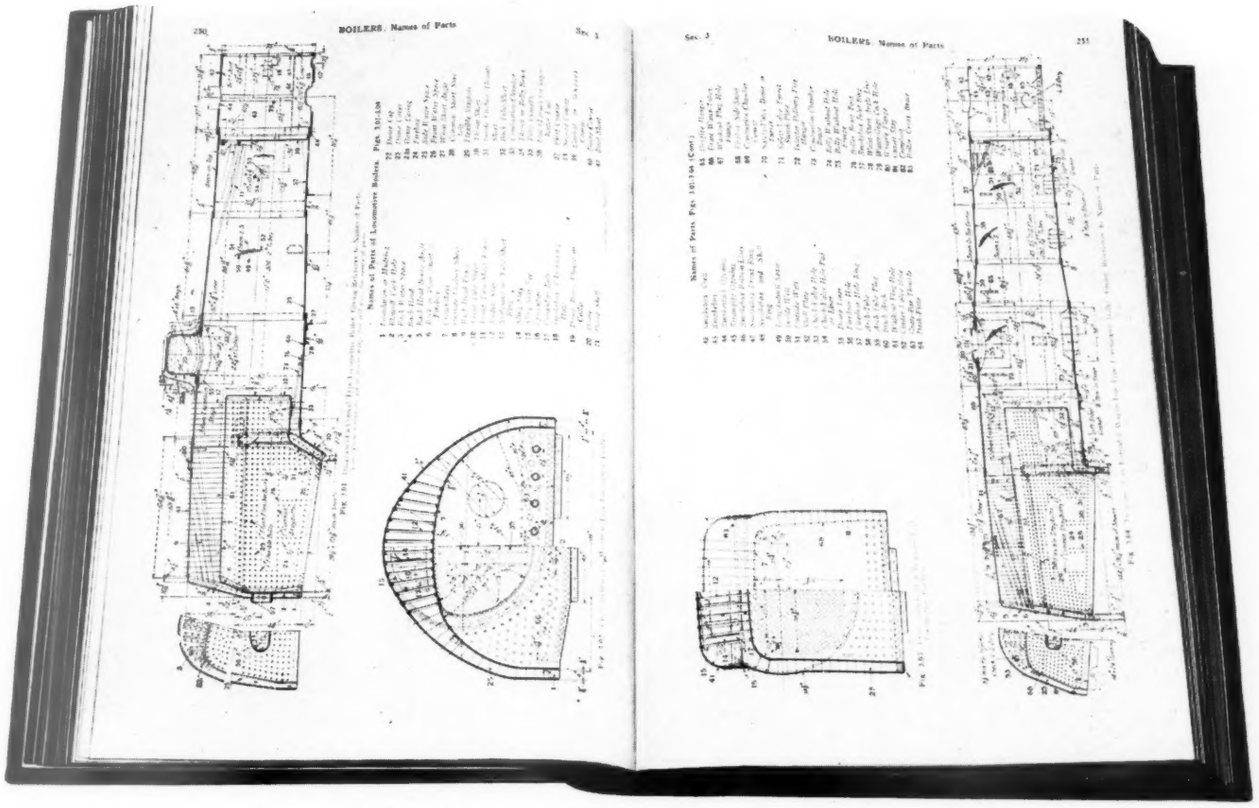

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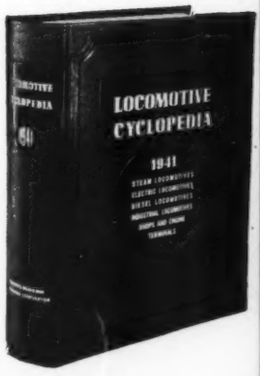

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4—Boilers; Water Supply

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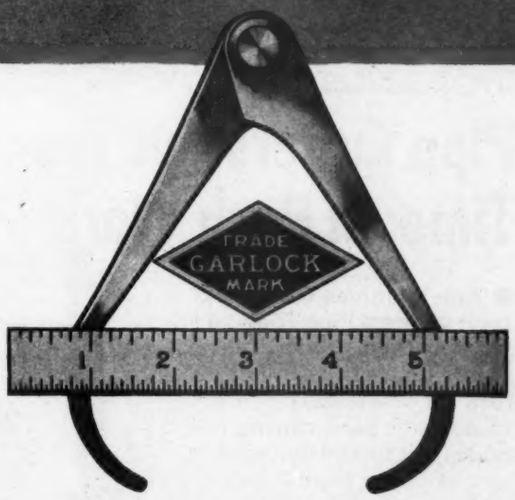
Efficient and economical plant operation is vital to attain the unprecedented production levels demanded by the National Defense program.

The dependability and long life built into every GARLOCK quality product today, as always, contributes to efficient plant operation by reducing production time losses due to shut-downs for frequent replacement of packings and gaskets.



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In Canada: The Garlock Packing Co. of Canada Ltd., Montreal, Que.

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From the 10 styles of Carboloy Standard-Stock Tools—now being manufactured in "mass production quantities" for "universal" use on turning, facing, boring jobs—Falk has selected 9 styles to maintain in stock in their tool room. When specials are needed, Falk adapts the "standards" by quickly grinding the shape desired. Usually no more than a 10-minute job per tool—and as easy to do as the average regrinding of dull tools.

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Non-slip twisted cross bars are forced into serrated bearing bars under heat and enormous hydraulic pressure. Both become one inseparable unit.

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RUNNING BOARDS and BRAKE STEPS

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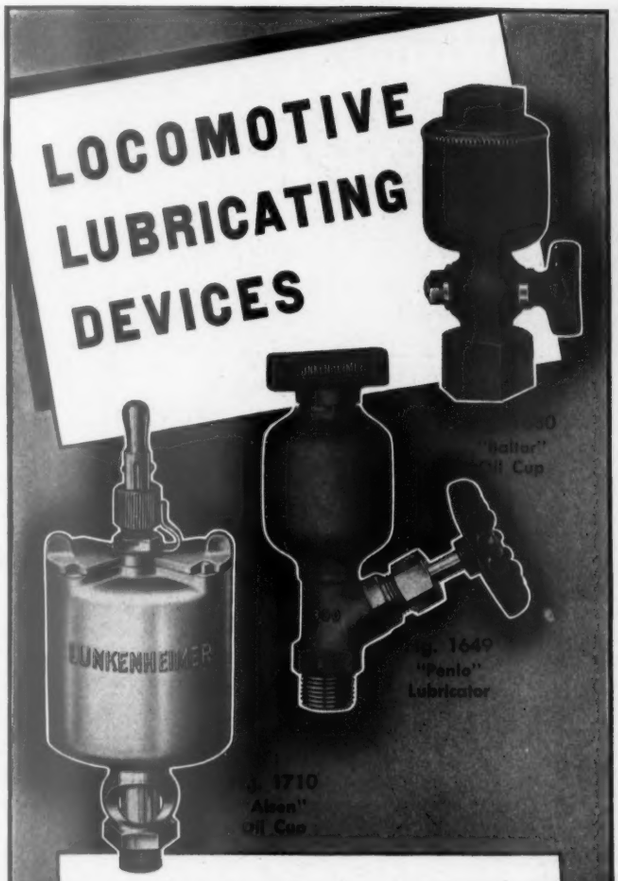

Lunkenheimer Fig. 1680 and Fig. 1649 are sturdy bronze cups designed primarily for the lubrication of power reverse gears, grate shakers, bell ringers, fire doors and stokers on locomotives.

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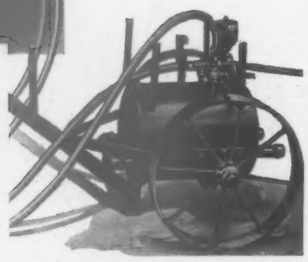

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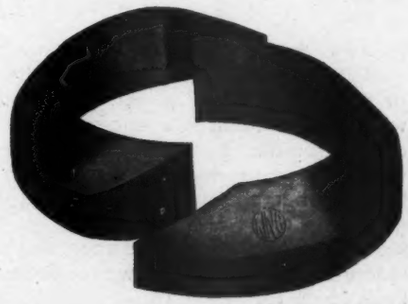

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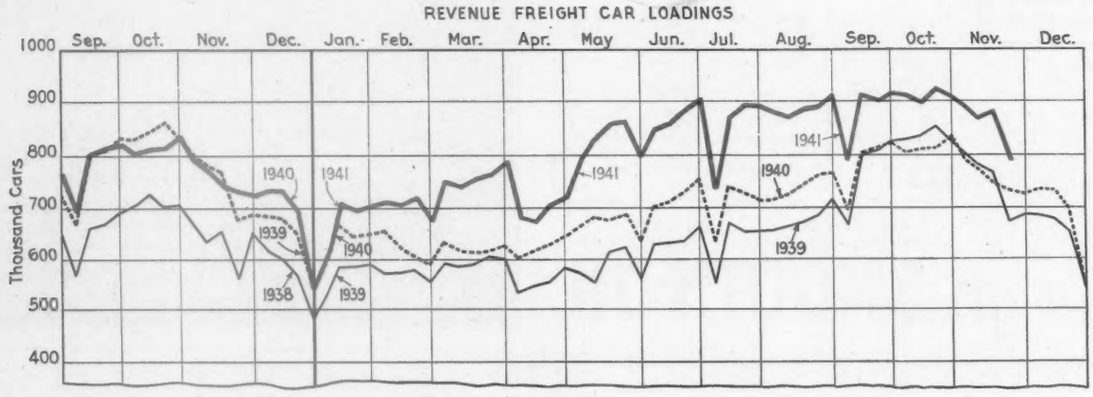
THE EDITOR'S DESK

STRATEGIC IMPORTANCE OF THE RAILWAYS

Railway officers and railway supply manufacturers are deeply concerned over the material situation, both for new facilities and equipment and for maintenance and repairs. Freight car loadings are continuing to maintain a high level and undoubtedly will severely tax the capacity of the railroads this winter, particularly if bad weather conditions are encountered. National defense production is speeding up steadily and while freight car loadings have fallen off from the October peak, they are now running at a much higher level proportionately, than they were in September and October, and except for unforeseen circumstances, will undoubtedly continue to do so.

The Railway Age, in a recent editorial, compared freight car loadings with the average loadings for the same months during the five-year period 1925-29, inclusive. In August of this year the car loadings were 82.5 per cent of the five-year average, in September 79.6 per cent, and in October 79.1 per cent. In November, however, although the actual car loadings were lower than those in October, they showed a marked increase in percentage over those for the five-year period. Complete November figures are not yet available, but for the three weeks ending November 15, the loadings were 84 per cent of the five-year average.



The New York Herald-Tribune compares the loadings each week with the average for the same week for the preceding ten years. The percentage increased from 121 for the week ended October 11, to more than 132 for the weeks ending November 15 and November 22.

This stiffening up of the traffic curve, as we come into the winter months, presents no uncertain challenge to maintaining the equipment in the best possible condition, and to adding new equipment as rapidly as conditions will permit — the builders are far behind their schedules at the present time.

Railroads are a vital link in the national defense chain. Apparently some of them are more fortunate in securing materials and equipment than others. It is the squeaking wheel that gets the grease and no possible effort should be overlooked in awakening the authorities to allocate strategic materials where they are so vitally needed.

Roy V. Wright

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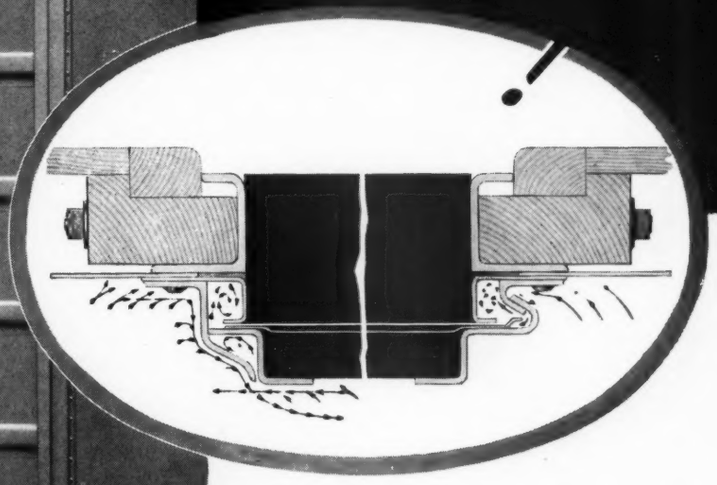

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